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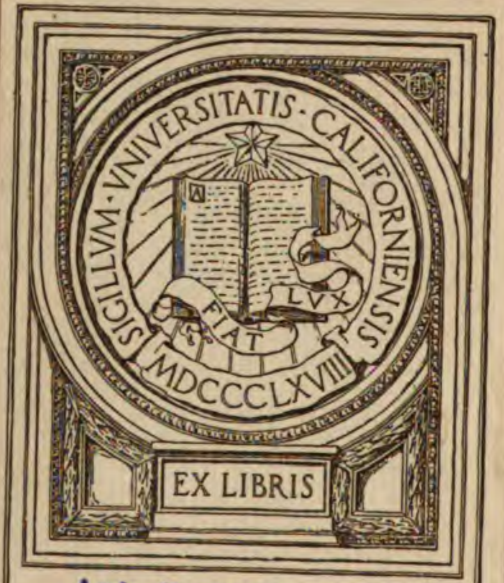

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The Case Against

The Single Tax

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Much as may be said of the impracticability and danger of the single tax delusion, its most effective dismissal is in the falsity of the assumptions upon which it has been built up. In all civilized countries poverty is diminishing, not increasing as it would if land ownership were operating as alleged. And it is the exception, not the rule, that land ownership brings any deplorable "unearned increment." On the whole, land has risen in value either not at all or insufficiently to compensate for the cost of holding it.

Western
Forestry and Conservation
Association

PORTLAND, OREGON
1915

FOREWORD

Increasing public interest in taxation problems sometimes confronts forested regions, whose welfare is largely dependent upon forest industry, with agitation for new systems framed without forestry in mind. It is not within the province of forestry organizations to quarrel with any of these insofar as they are sincere attempts to improve social conditions. As such, single tax should properly be left to political economists and to the community for decision as to whether land ownership is the only means by which capital exploits labor and is the source of all our social ills. But foresters and forest welfare do owe it to the public to speak when any measure advocated by those ignorant of or indifferent to forest conditions threatens the perpetuation of forest resources.

SINGLE TAX A DANGER TO FORESTRY

(From the adopted report of the Fifth National Conservation Congress, Washington, D. C., November, 1913.)

The single tax, applied to forests, forces cutting regardless of demand. This means the utter waste of all but the choicest part of the tree; the export to foreign countries, hence the loss to us, of the surplus above our present wants; and the early destruction of a source of tax revenue which should be stable and enduring. It also means the wrecking of the great majority class of lumbermen—the small independent men who have no great financial backing—and placing the control of lumber prices with those who are in position to take advantage of the situation without the slightest benefit to the consumer or any desirable effect of distributing forests among small hands, such as is argued by single-taxers in the case of farm lands. It means only over-cutting and, to accomplish this as economically as possible, only by the largest and perfectly organized operations such as require great capital. With respect to the growing of new forests, to supply the future consumer, continue a tax revenue, and to preserve streamflow, the result would be even more suicidal, for destruction of the project would be attended by no salvage whatever. The forests simply would not be grown.

The only alternative to these evils, under single tax, would be to separate forests from land absolutely, regarding the former as improvements, a distinction impossible to arrive at justly and practically under conditions grading from virgin forest to purely man-grown reproduction, with even the former existent to a certain but unmeasurable degree because of fire protection afforded by the owner. It is wholly unlikely that the public would seriously consider exempting all speculatively-owned forests from taxation. To continue regarding them as land, under single tax, would have the destructive effect described. To exempt them, but compensate by increasing the tax on the land which bears them, would require over-taxing identical land, now denuded but which should be reforested, so that reforestation would be impossible. Consequently, should single tax ever be considered seriously in any forest community, it will be highly necessary to exempt forest lands wholly from its application, either by continuing them under the old general property tax or preferably placing them under a yield tax system which, in effect, applies the income tax principle to this class of property.

THE CASE AGAINST THE SINGLE TAX

E. T. Allen

(An address before the State Tax Conference in Seattle, May 27-29, 1914, under the auspices of the University of Washington.)

I have been asked, rather unexpectedly, to marshal in orderly array the obvious answers to the single tax heresy. This is not a pleasing task for one of sympathetic nature, because in the first place single tax is not an argument, but a faith. People believe in single tax not because a thorough study of political economy, pro and con, leaves them no other decision, but because they have discovered a divine revelation which makes study of the other side irreverent. One hesitates to attack such a faith. In the second place, the answers are so many that the whole subject does not seem worth the time required to present them.

In the time I do have, however, I shall not ask you to listen to my own rhetoric but shall try to give a digest of the conclusions of the world's best thinkers who have studied all sides of the question, not as single taxers, or primarily as anti-single taxers, but as unbiased political economists.

Single tax is unjust. While it professes to return society-made values to society, it exempts the many forms of wealth which, quite as much as land values, are due to the existence of society. There is no such thing as individual production. All wealth is made by exploiting community-made conditions, including the needs and services of labor. The most ardent single taxer, who declares that the product of his brain, hand, and industry is his own, and consequently different from community-made values, owes his whole existence, is alive and heard today, only because society has given his wares a market. He and you and I, each alike, owe a debt to this society and should pay it, as taxes, according to our ability to pay. There is no justice in singling out land and sparing other society-made values. All are thus made.

Single tax is uneconomic. By confiscating land values it reduces land to a mere instrument for temporary use. This means abuse of the soil because cultivated by those without enduring interest in its fertility, also lack of land reclamation and development. These mean less food to supply consumers and higher food prices—attacks upon the community's very existence.

Single tax is dangerous. Aside from all its principles, it places the tax-gathering power—the most dangerous power in government—beyond the safeguard of common interest. With all classes but one exempted from any need of watching men or methods to prevent oppression, extortion and extravagance, a most corrupt and powerful machine is certain to follow.

Single tax is impracticable. It can not produce the required revenue. Whatever may appear from figures based on present land values, its effect must reduce such values to a point where they cannot support the tax. The poorer and less developed the community, the quicker will its tax sources be destroyed.

Single tax is ambiguous. It is incapable of the clear definition and understanding necessary to intelligent adoption or execution. It is based wholly on upsetting social conditions and bringing about new ones that cannot be accurately forecast. Instead of attempting to utilize the history of eight centuries of English-speaking people in tax reform, it attempts to bring about an untried situation and legislate for it in advance without experience. Naturally it cannot present any clear-cut working method.

Single tax requires impossibilities. It purports to spare values due to the land owner's personal effort, but in practice this cannot be done. What assessor can measure the labor and expense involved in cultivating or improving any tract unless he knows its exact original condition and of every hour and cent spent upon it later? No two tracts, however alike now, represent identically the same effort.

Single tax punishes the poor. The rich can evade its consequences, at least partially, for there are many alternative investments. But the wage earner whose sole hope of investment is in a home of his own, the farmer who knows no trade but using the land, the consumer whose food is to be curtailed in production and then subjected to speculators who can hold it without tax—these have no alternative.

Single tax says to the little investor as well as to the big one—to the wage earner who invests his savings in a home and to the settler who braves privations to acquire one: "You shall have no profit. Profit belongs to us." Will it also guarantee him against loss?

Single tax is an abandoned device for tax reform. All progressive countries are working toward taxing all wealth on the basis of its ability to pay. It is a proposal hundreds of years old, exploded every time it has been studied seriously, and now kept alive chiefly by funds contributed by enemies of true tax reform.

Single tax is seldom a home movement. The chief reason it is before most communities is that an Eastern millionaire, Fels, founded a fund supplying large sums for hired writers, speakers and petition carriers.

No good movement ever depended on paid agitators.

There is double cause to suspect agitation paid for by interests with no stake in the community.

There is treble cause when it seeks legislation to favor such interests at the expense of others.

Single tax exempts Mr. Fels' business and big business generally.

Single tax increases the farmer's and home owner's taxes. It destroys the value of their property. Both of these things, the last because of the first, are professed objects of single tax. Its breath of life is in attacking the morality of land ownership. It is by these things that it proposes to produce the millenium.

Single tax arrays against the small land holder all the personal prejudices that can be fostered against the large land holder. We may feel more charitable toward the former, but he is bracketed by single tax in a class deserving punishment. He will not always escape.

The tax gathering power, if unjustly used, is the world's greatest instrument for corruption, oppression, and destruction of individuals and industries. What safeguard remains for the farmer or home owner when all other classes are arrayed against him, exempt and without interest unless to profit by extortion, extravagance and political power?

Single tax does not help the wage earner. He pays practically nothing now upon his personal effects. It is his employer who will profit—the man who rides in automobiles and grows rich, **not by owning land but by exploiting the needs and services of labor.**

What the capitalist saves by single tax must be paid by land, passing the burden back to the wage earner in the form of higher food prices. More than that, the speculator in cornered necessities of life, paying no tax while holding them, can wait till the consumer pays his price.

Single tax exempts wealthy proprietors of great sawmills, factories and department stores, idle inheritors of great fortunes, middlemen, wholesalers who control the necessities of life, bankers and bondholders, liquor dealers and loan sharks, landlords of houses and tenements. Does this sound like a wage-earners' law?

Single tax professes to punish the great land and timber owners.

How? By taxing them heavily **before** conditions permit realizing anything on their investment, but after they get their millions allowing full enjoyment without being taxed at all.

Single tax says it seeks to confiscate rent, because rental values are community-made, and to exempt profits of individual effort. Examine this theory from a common sense business standpoint and ask how it is to be done. There is no such sharp distinction between rent and profit for the assessor to recognize. They shade into each other.

Rent may not endure, for land may lose as well as gain value. Though rent is chiefly due to growth of population, it is no more so than the value of any business, and the land holder without skill and effort to serve the community is more apt to lose than gain.

There are exceptions, made much of by single tax writers, but it is a rule that returns from land are made by those who use their capital, earnings or labor, rather than keep it idle, and who develop their property at individual risk and expense, instead of waiting for others or for the community to do it. This is true of the farmer, the home builder, the developer of city additions, and the reclaimer of desert or swamp. There are plenty of failures also.

Single tax denies these services and risks. At least, it cannot measure them. In order to guarantee the community all profit which might otherwise go to an exceptional lucky idler, it is obliged to confiscate them along with community-contributed values. It does this to no other form of human effort. Nowhere else is the investor asked to take all the risk, pay all society's taxes, give up any profit to society, and yet be unreimbursed by society if the venture fails. If it is denied that single tax does this, ask how the assessor is to separate rent and profit.

But here, and I ask you to mark it well, is the conclusive proof of the utter destructiveness of the single tax:

It will penalize the great middle class which constitutes society. While its advocates may make much of the "unearned increment" and point out a few fortunes acquired thereby, the fact remains that land is only to a small extent owned by the rich. These prefer more rapid means of money making, means which wealth can control. Land is chiefly owned by the farmer and the ordinary citizen who invests in a home or in land as a safe form of applying his earnings. It is the ruling passion of our people to own a home and, more than this, to invest their savings in something which is safely beyond the manipulations of their financial masters. They fear stocks, bonds, railroads, mines, and the like. They prefer security for old age, or for their widows and children, to be in the form of land and they save for this purpose. It is our national inducement to thrift. Consequently it is this majority middle class, not the rich speculator, which will have its all wiped out by any plan which reduces land values—a fatal blow to national prosperity.

VIEWS OF THE MOST COMPETENT AND WELL-KNOWN POLITICAL ECONOMISTS

The foregoing address by Mr. Allen presents in condensed form the unanswerable evidence against the single tax which is given by political economists the world over. For citations and elaboration the student is referred to the following digest of statements by such authorities, all of international and impeachable standing.

Alvin Saunders Johnson, Professor of Economics, Cornell University. Students are especially referred to his article in "Atlantic Monthly" for January, 1914.

Johnson concurs with political economists generally and adds some peculiarly convincing arguments. Perhaps the most striking is his demonstration that single tax would bear ruinously on the middle class, which constitutes the most useful portion of society. He shows that of all land in the United States, about four-fifths is owned by the poor and middle classes. While occasional large land fortunes can be cited, few rich men, after all, have the bulk of their fortunes in land. On the other hand, land is the one investment that the middle class can hold against the encroachment of the rich. It is the poor man's inducement to thrift and safeguard against distress. It is where his savings lie. Single tax will destroy this opportunity and confiscate these savings. To the claim that it will bring compensating relief from other forms of taxation, Johnson replies that since taxes other than on land aggregate less than half the land rent enjoyed by the middle class, and not more than a third of them now fall on middle class land-owners, obviously this class cannot recover by relief from other taxation more than a sixth of the loss imposed upon it by single tax.

Johnson emphasizes the certain injury of rural single tax to farmers, already underpaid and tending in the younger generation to seek the cities. He holds boldly that the "unearned increment" is now all that renders agriculture tolerable in a large number of instances and that its abolition will certainly make the most enterprising of the agricultural population cease to be food producers for city laborers and send them into competition with the latter for their jobs. Finally, he denies the claims of single taxers regarding urban values, holding them to be theoretical and that single tax cannot produce conditions so favorable to building as now exist wherever land is rising rapidly enough to promise protection of the investment.

Francis A. Walker, President Massachusetts Institute of Technology and author of Political Economy, Discussions in Economics and Statistics, The Wages Question, International Bimetallism, Land and Its Rent, etc.

In "Political Economy" treats the subject with brevity but great clearness, showing that if the state allows and encourages one to purchase land with his earnings, perhaps even selling him the land itself and putting the money in its treasury, and then by Henry George's proposed process takes away without compensation either the land or the right to its full rental, "it becomes simply a robber, neither more nor less." He also traces the growth of private ownership out of the original primitive tribal tenure of land and shows that, notwithstanding the abuse of power by which private ownership has frequently been established, the chief reason was that communal use is unproductive and unprofitable. He says common ownership has two fundamental evils: (a) The amount of political machinery required and the tremendous power for favoritism and corruption; (b) Abuse of the soil when cultivated by those without enduring interest in its development and preserved fertility, thus affecting the community's very subsistence. Gives excellent illustrations of this last point.

Richard T. Ely, Director School of Economics, Political Science and History, University of Wisconsin, and author of Taxation in American States and Cities, Outlines of Economics, Introduction to Political Economy, Labor Movement in America, French and German Socialism, etc.

Has a brief but telling reply in the book first mentioned above to George's assertion that what the individual produces by his own labor is his, therefore not justly taxable. Summarized, Ely's reply is this: "There is in modern society no such individual production as George assumes. What have I produced alone and unaided? Nothing. All modern production is social and the independence of the individual is felt in a thousand ways. Consequently society has a claim upon each and all."

W. M. Daniels, Professor of Political Economy in Princeton University, author of Elements of Public Finance.

Daniels points out that whatever be the fundamental justification of private property of any kind, there is no reason *a priori* why private ownership of land may not be as justifiable as private ownership of material chattels. Human labor is not the cause of the matter of any material product, only of its form, therefore if a man is to have the right of property in the product, he must have been allowed to appropriate the material which was as much a gift of God to humanity as land was. He disposes of the purely utilitarian side of the single tax theory (as distinguished from its ethical basis discussed above) by saying there is no historical or theoretical ground for assuming that the community's increase of productive power and consequent demand for factors of production applies in any fixed measure more to land than to capital or labor. Daniels also holds that private property (and he admits no difference in forms of private property) is the most efficacious method society has devised to minimize the suffering involved in the struggle for existence. It secures possibility for the greatest self-realization of the **rational persons who constitute society.** In his opinion, this is sufficient moral justification. His arguments are logical and scholarly, but not quite simple enough for the largest class of readers.

Carl C. Plehn, University of California, author of Introduction to Public Finance.

Plehn reminds us that the growth of taxation, based upon experience, has been toward greater complication rather than toward simplicity. The complexity of civilization requires this in the interest of both justice and expediency. No nation ever found any single tax feasible as a source of income; none at all advanced in civilization attempts to conduct its government entirely from the earnings of its domains or industries. Perfection lies in the way of a mixed system that combines benefit and faculty to pay with the greatest possible simplicity and universal justice. He says a single tax on incomes might be made satisfactory from a fiscal point of view but would fail to answer the simplest requirements of justice, and that single tax on land would not only be unjust and inexpedient but would also fail to raise the necessary revenue. He gives a few of the common arguments as to its injustice, but dwells chiefly upon its fiscal unsoundness, with figures to prove that no tax on land alone, sufficiently large to pay the entire cost of government, could be appropriated without quickly defeating its own end by ruining the user of the land and prohibiting its cultivation.

Edward Sherwood Meade, Professor of Finance, University of Pennsylvania, author of Economics, Trust Finance, The Story of Gold, etc.

In "Economics," Meade shows that pecuniary needs of government rise and fall, while rents do not change with the same rapidity, consequently that single tax would alternate between surplus and deficit. Also that it could not be collected. Much of land value is due to improvements. The returns from capital and labor thus invested could not be segregated, hence such a tax could not be fairly applied, especially to agricultural land.

Poverty is rapidly diminishing in every civilized country, which contradicts the assumption upon which the single tax theory is erected. Wages are paid by an employing class, and the larger the amount of capital seeking investment the greater the demand for land and labor, which explains the general rise of wages all over the world. A large amount of this increased demand for labor comes from landlords who do not consume all their income from rents but who save and invest a large portion in producing capital. Land is not the only monopoly; there are other unearned increments besides rent. The abolition of one form of monopoly without attacking another is inconsistent. Single tax strikes at the foundation of society by attacking the institution of private property. If the landowner may be deprived of his land, owners of all other forms of property may well feel insecure.

A. T. Hadley, President of Yale University, formerly Professor of Political Economy, sometime Labor Commissioner of Connecticut, and one of the most prominent living experts on social and economic problems; author of Railroad Transportation, Its History and Laws; Economics, etc.

His discussion of single tax in "Economics" is notable for common-sense business-like treatment instead of theoretical argument. He shows the impossibility of making any such sharp distinction between rent and profits as the single tax theory contemplates. They shade into each other by insensible gradations. Rent cannot be regarded as enduring for all time, for land may lose value as well as gain it. Though rent is chiefly due to growth of population rather than to the controlling hand of an individual, a speculator without special skill in serving the public is more apt to lose than gain. With exceptions, of course, it is a general rule that large returns on real estate have been made by men who used their capital or earnings, rather than kept it idle, and who developed the property at considerable risk instead of waiting for others to do it. There are plenty of failures. Single tax proposes to deprive the investor of any surplus above the current rate of interest. Would it also guarantee him against loss? Loss and bad management of real estate are large now, they would be greater if shifted to society as a whole.

It is not a legal possibility to overturn recognized rights without compensation. The existence of law depends upon the continuity of its application. It is an axiom of political science that private property, whether unearned increment or anything else, must not be taken without compensation. If for this reason the fiscal success of single tax is questionable when applied to past unearned increment, how much more so if we deal with the future only, without knowing what land values will be?

Charles Gide, Professor of Political Economy in the University of Montpelier, France, a recognized European authority.

Gide's attitude toward single tax is more clearly expressed by his advocacy of wholly different principles than by his direct discussion of it, but he says this emphatically enough:

> "The great practical objection to this plan is that there are usually two elements in the surplus value of land: one arises from the social and extrinsic causes already set forth, but the other may result from the owner's labor and from the advances he has made. Were we to establish such a tax, we should have to be careful to abstain from touching this second element; nor only for fear of violating the principles of equity—for this portion of the increment is the product of labor—but also for fear of discouraging all initiative and all progress in agricultural operations, which, we are aware, even now go too much by way of routine. Now it is impossible to follow out such a plan."

Henry Carter Adams, Professor of Political Economy and Finance, University of Michigan, author of The Science of Finance and one of the best known American students of public expenditures and revenues.

In "The Science of Finance," Adams first discusses single tax in its relation to land policies, rather than as a source of revenue, and points out that by removing motive for land owning except in connection with occupancy, its logical result is a tenant system with the state as landlord. The acceptance of this as beneficial would be a reversal of eight centuries of the history of English-speaking people. He shows that at least as a proposition for solving the labor problem, and hence effecting social reform, it does not bear the test of analysis. The question at issue is whether transfer of ownership to the state will make "free land" in the sense that the labor will always have the opportunity to create his own wages by working on land instead of working for an employer at wages offered. Adams says this has but one answer. Land is no more accessible by the landless when its full rental value is demanded by the state than when the interest for its purchase money is demanded by the money lender. Anyone who can guarantee the interest on a sum on money equal to the capitalization of the annual rent can secure land under the existing system. What more can he do should the state, as proprietor, demand annually a tax of 100 per cent upon the rental? In short, a tax on **rental value** to its full amount, which is what single tax proposes to prevent landlordism, cannot change the level of wages, or establish a national law of wages, or enlarge the liberty of the worker.

Finally, Adams illuminates, in much the terms of others, the obvious error of assuming that the influence of social evolution upon values is confined to real estate, and of overlooking both the duty of other classes of property to pay for special service received and the administrative inexpediency of a single tax to support separate civil divisions of government.

Edwin R. A. Seligman, Professor of Political Economy and Finance, Columbia University, author of Essays in Taxation, The Shifting and Incidence of Taxation, etc., and perhaps the widest quoted at home and abroad of any American authority.

In Seligman's classic Essays in Taxation a full chapter is given to single tax. Its history as a movement since its inception in Europe in the seventeenth century is analyzed, and the arguments for and against are weighed clearly and impartially from practically every viewpoint. By what would seem to be irrefutable logic he proves the theory defective from all; practically, fiscally, politically, ethically and economically. On the whole, his facts and arguments are like those of the other writers quoted, although carried into greater detail. He gives particular attention, however, to the effect upon poor and new communities, upon farmers and agricultural interests, and upon the poor in rich communities. He emphasizes that while the poor backwoods or rural community (that is, poor in taxable values) will be utterly unable to raise revenue for current expenses and improvement, it cannot hope to share the revenue raised in richer communities because the latter will never relinquish them voluntarily and, having the power, will escape compulsion. Every county and town must stand on its own feet, and if the single tax is unable to defray even the local expenses of a poor community, not to speak of its share of general state expenses, it is clearly beyond the realm of practical politics. He predicts destruction of the one class above all others upon which our prosperity rests—the class of independent small farmers. He denies that the inhabitants of congested portions of large cities would be relieved of rent burden or discomfort by stimulation of suburban building, for the reason that rents are already lower in the suburbs than in tenements, but the latter are none the less crowded. This is largely a question of convenience and transportation cost. Moreover, since wages can be increased only through increase either of capital or efficiency, no system of taxation can improve them. This chapter in its entirety constitutes one of the most complete, simple and readable refutations of single tax, but is too cumulative in its logic to afford ideal quotations except, perhaps, its concluding page:

"We have learned first, that it would be inelastic, and that it would intensify the inequalities resulting from unjust assessments; secondly, that although itself proposed chiefly from social considerations, it would prevent the government from utilizing the taxing power for other social purposes, and that it would divorce the interests of the people from those of the government; thirdly, that it would offend against the canons of universality and equality of taxation, and that it would seriously exaggerate the difference between profits from land and profits from other sources; and, finally, that it would be entirely inadequate in poor and new communities, that it would generally have an injurious influence on the farmer, and that even in the large urban centres it would exempt large sections of the population without bringing any substantial relief to the poorer classes.

"It is clearly impossible to discuss in this place the wider claim of the single-taxers, that the application of their scheme would introduce the social millennium. If economists thought that the distinguished single-tax leader had solved this problem, they would enthrone him high on their council seats; they would reverently bend the knee and acknowledge in him a master, a prophet. But when he comes to them with a tale that is as old as the hills; when he sets forth in his writings doctrines that have long since been refuted; when in his enthusiasm he seeks to impose a remedy which appears to them as unjust as it is one-sided, as inconsistent as it is inequitable—they have a right to protest. This is not the first time that some enthusiast has supposed that he has discovered a world-saving panacea. The remedy for social maladjustments does not lie in any such lopsided idea; the only cure is the slow, gradual evolution of the moral conscience of mankind. We cannot solve the labor problem by any rule of thumb. Every student of history, of political philosophy, of economics, will tell us that the progress of the race has been slow and painful; that the world has advanced step by step; and that each successive step, to be enduring, must be founded on justice. To suppose for a moment that the social millennium will be ushered in by any one sudden change—even were the change not so lamentably inadequate as the one above discussed—is an evidence not of wisdom, but of short-sightedness.

"Even as a method of tax reform, the scheme is, as we have seen, a mistaken one. Our system of taxation is far from being ideal, or even comparatively just; for we are still clinging, in a great degree, to mediaeval errors. But whatever be the much-needed reform, it is safe to say that neither the common people nor the student will ever accept a scheme which is palpably unjust, which abandons the whole ideal theory of modern taxation—that of relative ability of faculty—and which seeks to put the burdens of the many on the shoulders of the few."

One principle regarded as axiomatic by all these writers—that because there is no such thing as individually-produced wealth for which he owes society nothing, every citizen should bear a share of the cost of government—has been put very well by no less an authority than Huxley, who said:

"I cannot speak of my own knowledge, but I have every reason to believe that I came into this world a small, reddish person, certainly without a gold spoon in my mouth, and in fact with no discernible abstract or concrete 'rights' or property of any description. If a foot was not at once set upon me as a squalling nuisance, it was either the natural affection of those about me, which I certainly had done nothing to deserve, or the fear of the law, which, ages before my birth, was painfully built up by the society into which I intruded, that prevented that catastrophe. If I was nourished, cared for, saved from the vagabondage of a wastrel, taught, I certainly am not aware that I did anything to deserve those advantages. And, if I possess anything now, it strikes me that, though I may have fairly earned my day's wages for my day's work, and may justly call them my property, yet, without that organization of society, created out of the toil and blood of long generations before my time, I should probably have had nothing but a flint axe and an indifferent hut to call my own; and even those would be mine only so long as no stranger savage came my way. So that if society having—quite gratuitously—done all these things for me, asks me in turn to do something towards its preservation—even if that something is to contribute to the teaching of other men's children—I really, in spite of all my individualist leanings, feel rather ashamed to say 'No'. And if I were not ashamed, I cannot say that I think that society would be dealing unjustly with me in converting the moral obligation into a legal one. There is a manifest unfairness in letting all the burden be borne by the willing horse."

THE SINGLE TAX: IS IT A PANACEA FOR POVERTY?

(An abridged article from Brann's Iconoclast.)

The single tax is the antithesis of a paradox—apparently true, but really absurd. To say that all men are born with an equal right to natural resources is to state a general truth, but one of no more practical importance, either in ethics or economics, than that the sky is blue or water is wet. God is all-wise. God made man; man is a land animal. "From these premises it follows" (say single taxers) "that whatsoever abridges his free access to the land is, to that extent, an abrogation of his natural rights and an insult to Omniscience." The same all-wise God made the panther, and the panther is a carnivorous animal; therefore it has a natural, an inalienable, right to kill and devour anything, from a cotton-tail to a single taxer!

Mr. George complains that critics of his system lose sight of fundamentals—are confused and misled by the complexions of modern society--yet there is one great fundamental which he has not yet found. Man is a gregarious, not a anchoretic, animal. Society is both natural and necessary, but it can in no wise exist without a material abridgement of the "natural rights" of the individual. Labor must be applied to land before it will yield subsistence, and to apply it profitably requires organization. While land is the creation of God, the social organism is the creation of man, in which the newcomer can plead no natural rights. He is entitled only to such place therein as he earns.

Mr. George complains that all land titles are founded in force and fraud—that not one of them can be traced back to the Creator. Quite true, but it is by force and fraud that man dominates the lower animals, which have as good "a natural right" as himself to the enjoyment of life, liberty and the pursuit of happiness. It is by force and fraud that he makes the horse to carry him, the cow to feed him and keeps his babes from the ravenous jaws of such wild beasts as seek to exercise their "natural rights."

I do not plead that landlordism is never an evil; it is frequently an outrage. But before condemning our land system in toto, it were well to inquire whether this be the rule or the exception. We find, on examination, that while a few have been enormously enriched by the increase of land values to which they contributed little, many who contributed much have become impoverished; that the American land owner, collectively considered, instead of being an all-devouring octopus, receives but a beggarly return on his investment. We find that there has never been a time since the organization of this government when the "unearned increment," of which we hear so much, and which Mr. George proposes to confiscate for the public benefit, would pay the taxes laid upon the land. By "unearned increment" I mean—and understand Mr. George to mean—the increase in market value of landed property. Take the land tax paid during the past 100 years, compound it annually at the prevailing commercial rate, subtract the present market value of every foot of American soil exclusive of improvements and you'll have enough left to buy the royal vermin of Europe. Government is already taking the "unearned increment," and taking it twice told, hence instead of the landlord being a leech on society, it is a leech on the landlord. Of course the landlord as landlord produces nothing, the mulct is taken from the product of labor as applied to land. The owner of a railway, a factory or a million gold dollars produces nothing as owner, the increment arising solely from use. Land must yield the owner a rental somewhat in excess of taxes and cost of superintendence, else he would release it.

"Rent is simply interest paid upon land values by the user. As the earth was evidently made for the use of all, is that system defensible which enables one man to compel another to pay him for using any part thereof? As the community creates land value, may it not properly confiscate it?" Let us see:

I move far beyond the confines of civilization and there make myself a home. Other settlers follow until there is a community of a hundred families. Men congregate for mutual aid and society, and my land becomes the center of the settlement, and therefore the most desirable. Homes spring up around me in an ever-widening circle. When we have endured all the privation of pioneers, when we have driven off the Indians and slaughtered the wild beasts; when we have become sufficiently numerous to maintain a blacksmith and a doctor, a schoolmaster and a preacher, and are beginning to enjoy somewhat the sweets of civilization, Mr. George concludes to make his home among us. But he is not willing to take his place in the outer circle—he wants to get in the center. As I am growing old and can no longer use all my land I offer to part with a "forty" for a consideration, or I will lease him the land for a sum which in the opinion of home-seekers makes the difference between its desirability and that of the best land still open to settlement. Mr. George demands to see my title to the land, signed by the Almighty.

He tells me that, being a land-animal as well as I, he has an equal right of access to the earth. He assures me that the desirability of my land is due to the presence of the community, and that the benefits received and contributed by the new settlers are co-equal. He secures the passage of a law confiscating all ground rent, and thus begins where I leave off after the isolation, dangers and trials of half a lifetime.

That land values do not yield an average return of 3 per cent will appear on a moment's consideration. For various reasons land is the form of investment most popular with the people. It is usually considered safest, and the veriest tyro in economics knows that investment considered safest yields the smallest increment. Thus, government can borrow money at 2½ and great corporations at 3 and 4, while private individuals must pay from 5 to 15. A certain dignity and additional political privileges pertain to land-ownership. You can sell a man land that has not budged a peg in value for 50 years, and which he knows will not yield him 3 per cent above his taxes, when you cannot borrow his money on gilt-edge security at 6. Banks may break, merchants fail, corporations collapse and government be subverted, but the land is always in evidence. It can neither burn up nor blow away.

But the earliest economists noted that land owners were content with smaller returns than any other class of investors. The great financiers have ever considered the soil as the poorest possible investment. The mortgage companies do not want land. When they chip a segment of the earth's surface from under you in lieu of money loaned, they throw it on the market. Were the landlord the chief of robbers, they would gobble up all the realty they could get. The great money lords will buy bonds at 2½ to 3 per cent, when in every state hard-pressed landlords are offering to sell at a sacrifice. If the man who wants the use of land, whether to plant hogs or grow a business block, will lease and loan his money, will pay rent and draw interest—he will save it five times in six. You can get at least 6 per cent for your money and dodge taxation, while not one acre in a dozen nets the owner so much.

The three factors in the production of wealth are land, labor and capital. The latter may properly be classed as a factor, as without it man is reduced to primitive methods of production. The landlord increases in wealth but slowly, labor is often on the verge of starvation; but the capitalist is able to give Bradley-Martin balls and buy dukes for his daughters. This argues that he despoils the other two factors of production. How does he do this? Much as Joseph, the first monopolist of whom history makes mention, despoiled the ancient Egyptians. He has cornered, if not the subsistence of the country, what amounts to the same thing. He is master of our tools of trade—of the money, machinery and transportation facilities. No matter how much land and muscle you may have, without the co-operation of capital you cannot profitably produce. It is an easy matter to obtain the use of land; the trouble is to obtain the use of capital.

How would the single tax afford people easier access to the earth—enable us to so multiply capital that it begs for employment? Under the present system, when you have acquired a piece of land it is exchangeable wealth, enables you to command any other form of wealth in the world. If you exchange gold or labor for land, you can exchange land for gold or labor; and wherein is the giving of value for value any more to be decried that the giving of nothing for nothing? I am told that if one does not have to purchase land he may put his capital or labor in improvements. Quite true; but he may do that as well under lease from the private owner as under lease from the government. If a change from private to public landlordism would reduce the rent, that were a point in favor of the poor; but if it does this, how will it compel the release of land now held for speculative purposes? If we are to meet all governmental charges, both general and local, from ground rent, and it amounts now to but 750 millions, it must be doubled instead of reduced. And how will the man who cannot pay $5.00 an acre rent, manage to pay $10.00? True, he will be relieved of all other taxation, both direct and indirect, but will this offset a raise of $5.00 an acre on a 40-acre farm?

Mr. George has refined his logic too far for any practical purpose in assuming that land is the source of all wealth. Technically this is true, but only technically. One great trouble with the single taxers is their ambition to save the country by the science of definition. Logomachy will never make two pieces of pie to grow in place of one sun-burned potato. The product of the land is, for the most part, merely potential wealth. The taxes taken by government are estimated in money, but are in reality a portion of labor's annual product. They are so many pounds of sugar and soap, so many barrels of molasses and bourbon, so many watches and wagons. The raw material for all these things comes from the soil, and they are made on the earth's surface to be sure; but while the prime factors in the production of a $10.00 log are labor and land, the prime factors in its transmutation into a $500.00 suite of furniture are capital and labor. Government might as well ask a horse for furniture as to require it of the land and the logger. They have not produced any furniture; they have only produced a log. Mr. George's government would resemble the country editor who is trying to run a paper on cordwood and cabbage. But the land occupied by the furniture factory would be taxed. Quite true, but a factory producing a million dollars' worth of goods per annum may occupy land of less value than a 10-acre farm. The man who produces five bales of cotton may pay more rent than the man who manufactures 500 into muslin. Mr. George is going to the wrong place for this revenue. But he is a professing Christian, and doubtless thoroughly scriptural, for the Bible says that "From him who hath not shall be taken even that which he hath."

You may theorize until the cows come home, but you cannot extract sunbeams from cucumbers nor blood from turnips. Taxation being but a toll taken from the product of each, the government may appropriate a part of the farmer's potatoes but cannot pull his leg for a piano. "Without land to produce raw material, there could be no wealth; ergo, land is the source of all wealth and the one proper subject for taxation." Without rain the land would be sterile, but for the ocean there would be no rain; ergo, the ocean is the source of all wealth, and will please step up to the captain's office and settle!

Wealth consists of things adapted by labor to the wants of man. It is upon the brawn and brain of the human race that society and government rest. The land, like the atmosphere, like time and space, is merely an incidental, economically considered. You can no more tax the land than you can tax the moon, which, like the "cat" of the single taxers, is by no means where it appears to be, the line of vision being oblique. I may have 50,000 acres of land, and all the tax-chasers this side of Sheol cannot collect 50 cents from it. They can only confiscate a portion of what labor produces thereon. If it produces nothing they can fine me for possessing it, but to meet this mulct I've got to produce—or steal—something desired by others.

Ever since I can remember, this country has been full of people who were "land poor"—people who were working themselves to death to pay taxes on land that nobody seemed to have any use for. Millions of dollars are paid into the treasury every year by holders of unused land simply because nobody will buy or lease. Under the George system all taxes will be taken off idle lands and placed on that in use. Why does fertile land often lie idle in states like

Ohio and Illinois? "Rent so high nobody can afford to pay it?" Oh, no! We have seen that it is cheaper for a man to rent land than to own it. Idle land presses for employment just as do capital and labor. When its owner cannot get much, he will take little. Rent can never remain exorbitant in a community where there is always considerable idle land. It would undoubtedly do so if one man, or a syndicate of men, owned the earth. In that case the landlord would dictate to both capital and labor. But such a condition does not, never did, never can exist except in the uneasy dreams of the single taxers. I defy any man to organize a landlord's league sufficiently powerful to raise the average ground rent one iota in a single American state.

"Land monopoly!" What is a monopoly? It is, says Webster, "exclusive possession." Who has exclusive possession of the earth? Nobody. Some millions of people, each acting independently and for his individual interest, own the arable land of America—and to the south of us, a few hours' sail from New York, Galveston and San Francisco, is a vast and fertile continent where land may be had for the asking. True, it is not provided with macadamized streets and cable-cars. It is well-nigh as wild as was Virginia when our ancestors struggled in there from everywhere. If the single taxers will migrate thither and take chances with the aborigines and wild beasts for a century or so, I will not question the right of their descendants to charge newcomers somewhat for the privilege of enjoying the blessings of a civilization founded by their fathers.

If the world were peopled up to something like its ability to sustain life, Mr. George's system would deserve more serious consideration; but land owners cannot grievously oppress labor or dictate to capital until they form an effective "combine" or the demand for land exceeds the supply. Can high wages exist when the supply of labor exceeds the demand? Can high rents exist when there are not men enough living to utilize half the land? Is population increasing so rapidly? During the present century there has been a vast gain in America, but a marked decline in many foreign countries. London has risen, but Babylon has fallen. San Francisco and Sydney are of the present, but Memphis and Palmyra are of the past. Not for ages hence will the fears of Malthus be realized, nor will the great-grandsons of Henry George live to see a "monopoly of land." It is idle to urge that the poor cannot emigrate from where land is dear to where it is either cheap or free, for it is ever the poor who do emigrate. America has been peopled by the poor.

If the landlord possesses the power to despoil the laborer and the capitalist—to compel them to yield him the bulk of their earnings or drive them into the ocean or off the earth—how comes it that men occupying land of little value, and that often upon lease, can form combinations that fix the price of the land products? A man possessing $100,000,000 may occupy a flatboat anchored in mid-ocean yet take a heavier toll from the annual product of labor than can the man who owns 1,000 acres of land in the heart of Ohio. The American landlord and the American laborer are paying heavy tribute to men who reside in Europe on land that would not grow bunch grass. The American landlord has no more power over them than though they made their home in the moon or existed in the atmosphere. The relatively rich and poor we have had with us since the dawn of history, but not until the change in productive methods, making necessary the co-operation of vast capital, did we see scores of men become suddenly richer than sceptred monarchs, while others, able and willing to work, are compelled to beg their bread.

The foregoing are a few reasons why I am inclined to doubt the efficacy of the single tax.

SINGLE TAX (?) IN BRITISH COLONIES

Single tax advocates frequently refer to British Columbia, Alberta and New Zealand as successful illustrations of their theory. As a matter of fact these colonies do not have single tax, their revenues being derived chiefly by taxes other than on land and including the income tax, which is diametrically opposite in principle. They have, however, for purely local reasons (mainly to discourage alien ownership, which is a problem there not paralleled with us) experimented with exemptions upon land improvements. Such exemptions transfer an insignificant proportion of their entire taxes to land, but, even at that, it has had far from a beneficial effect upon the affected municipalities. And to claim a growing sentiment toward universal single tax is direct misrepresentation. W. Downie Stewart, the leading New Zealand tax authority and co-author of "State Socialism In New Zealand," says not only that single tax has never become an issue in that country, but that no one of responsibility would ever dare advocate it in a community so pre-eminently agricultural. New Zealand is an income tax country, drawing a bare trifle of its revenue from a low graduated land tax designed to prevent English ownership of too great areas. As to the experiments in Western Canada, we quote two reliable investigators, one Canadian and one American.

F. C. Wade, King's Counsel, Vancouver, B. C.
(In Vancouver "Sun," January 7, 1914.)

We are expected to forget that the customs receipts for Vancouver alone—consisting entirely of taxes on the products of man's industry—amounted in the year just closed to $8,235,273.19, while the inland revenue tax was $666,237.48. The entire Dominion is financed by taxing the products of industry. If all the skyscrapers and apartment houses in Canada were exempt from taxation, the whole expenditure of the Dominion would continue to be provided by taxes, direct or indirect, on the products of human industry.

Similarly, persistent effort is made to mislead the gullible portion of the electorate by mixing up the Vancouver system of taxation and the Henry George theory. Henry George is a name to conjure with. Many who have never read a line of Henry George, will rush under anything held up as a Henry George banner. As a matter of fact there is no resemblance between the Henry George theory and single tax, as we have it in Vancouver. The Henry George system precluded all customs taxes, all inland revenue, as well as income taxes, personal property taxes, poll taxes, death taxes and all the other exactions, which we have to bear in Vancouver. Rent alone was to pay all the taxes of the community under the Henry George system. By single tax he meant one single solitary tax, and no other. Here we live under a dozen systems of taxation. Each one of the twelve may be single, but the aggregate, for all that, is none the less.

All we have to do with here is a system which exempts buildings from taxation and places the civic taxation on the land. This, we are told, is not only an equitable system of taxation, but one particularly favorable to the poorer man, and those less able to carry its common burden.

To what extent will this claim bear investigation. The assessment value of buildings for 1914 is $76,215,783. On these millions no taxes will be paid. To what extent does this exemption benefit the poor and the rich man respectively? An analysis of building permits should provide the answer. From January to October, inclusive, 1913, they were as follows: Permits for (1) rooming houses, $1,216,179; (2), factories and warehouses, $1,833,008; (3) offices and stores, $5,249,996; (4) private houses, $1,589,257. The first three classes will have to be credited to the well-to-do section of our population. They aggregate $8,299,183. Of the $1,589,257 expended on private houses, let us assume that two-thirds of the total was expended by the wealthier classes. In that case, $529,752 was expended on dwellings by the poorer classes and $1,059,504 by the well-to-do. The total exempted from taxation, therefore, would be $9,988,440, of which the poor man's total exemption would be $529,753. In other words, about seventeen-eighteenths of the exemption is in favor of the wealthier classes, and one-eighteenth in favor of those not so well provided. Applying this ratio to the total exemptions of buildings for 1914 we find that while the poorer man is exempted on $4,234,209 improvements, the wealthier classes escape taxation on $71,981,574. Let us carry the comparison still farther, using the same ratio. The system of totally exempting buildings from taxation has been in vogue since 1910. The grand aggregate of "improvements" exempted since then amounts to $267,172,837. Out of this grand aggregate the poorer man secured exemption on $14,842,935.38 in buildings, while the exemption of the wealthier classes amounted to $242,329,897.62! This system of taxation is called the poor man's boon! We hear nothing about the rich man's boon.

Let us look at it in another way. Under this system the lot which supports the modest residence or store, or no building at all, for that matter, must pay the same tax as the adjoining piece of ground, carrying a sixteen-story sky-scraper. The one may bring in little or no revenue. If reserved as a garden or lawn it must bring in nothing, and bear the cost of up-keep. The neighboring sky-scraper is a city in miniature. The rents are high and only those who are well-to-do can occupy its palatial offices. A bank and a trust company may use the ground floor, paying a prince's ransom by way of rental and the other floors are allotted to insurance companies, financial agents, loan companies, and professional men. In the sky-scraper is hived practically all the great money-making agencies of the city. Not one of these pays a cent of civic taxation on the building. If the structure is centrally situated and fully occupied, the landlord can count on anywhere from 25 to 40 per cent annual profit. Yet he pays no tax on his money-making "improvement." For his fire protection, police protection and other civic services he contributes not a sou. His neighbor with the vacant lot, which requires neither fire nor police protection, nor many other civic services, pays equally with him into the civic exchequer. One of the four great maxims, or axioms of political economists the world over, is that taxation shall be equal. "The subjects of every state," they say, "ought to contribute to the support of the government, as nearly as possible in proportion to their respective abilities; that is, in proportion to the revenue which they respectively enjoy under the protection of the state. In the observations of neglect of this maxim consists what is called the equality or inequality of taxation." Why have we departed from this principle? The excuse given is that all taxes should fall on the land because of the "unearned increment." Let us see how this applies. There can be no question that the man who can afford to build a fourteen-story structure multiplies the size of his land by fourteen. From an earning standpoint he multiplies it by eight or ten, as against the earning power of a one-story building. The increment becomes eight or ten times as large. A great deal of the increment is earned by the investment of his capital, but a great deal of it is unearned and a great deal of it is adventitious, owing its value to central situation, traffic and the very same influences which add "unearned increment" to the land. If anyone imagines that the capitalist earns nothing but interest on the cost of his bricks and mortar, let him put up for a week at a west-end hotel, or rent a suite of rooms in a fashionable apartment block. Why should not the unearned increment pay in the one case as in the other?

One of the great advantages claimed for the exemption of "improvements" is that it ensures a compact city. This is evidently the view of the building inspector. "The most prominent feature in connection with the building returns of Vancouver," he says, "is shown when the area covered is compared with other cities.

"From returns at hand I find per square mile of area, Vancouver leads every city on the continent of America." This is his proud boast. It is in order now for some one to point with approval to the huddled condition of London before the fire, or to hold up the most crowded quarters of Canton as a model to the world. This alone should condemn the system. That it has the effect claimed for it, no one can deny. The taxes on gardens, lawns and open spaces are prohibitory. Everything must be built up. Every open gap must be closed. We must have a compact city. Rather than expand our area let us build 200 feet in the air and immure our wives and children in apartment blocks and deprive them as far as possible of every beautiful and healthful natural surrounding. At the same time we are likely to have some trouble in escaping from the conclusion that a crowded wooden city is a standing invitation to fire, and a menace to the health and enjoyment of its population. The cry for open spaces is a necessary result of the stupid policy pursued, Park sites and improvements have already cost $1,260,600, notwithstanding that we have in Stanley park a recreation ground said to be equal in value to the national debt.

To some of socialistic tendency the policy of heaping taxes on the land appeals on the ground that it will force the land owner to let go his hold and cheapen the price of real estate. We have been pursuing the policy of partial or total exemption of improvements and transferring taxes, partially or wholly, to the land since 1895, so that there has been plenty of time to see the results of the experiment. The assessment rose from $76,881,820 in 1910 by leaps and bounds to $150,629,410 for the present year. It does not look as if even all the unjust and exorbitant taxation which has taken place has had the desired effect. Even had it accomplished what was hoped for, it must not be forgotten that heavy taxes imposed for the purpose of confiscation, will fall just as heavily on him who buys as on the vendor who was forced to sell. What benefit is conferred on the poor man by such a system?

In support of the system it has been continually claimed that we have been able to carry it on without increasing the rate of assessment by a single mill. In this there is not a word of truth. From 1895 to 1905 50 per cent of improvements were taxed. From 1906 to 1909 25 per cent were taxed. Since 1910 all have been exempt. When the exemption was 50 per cent the tax went up from 16 to 18 mills. When the exemption was increased to 75 per cent the general rate went up from 18 mills to 20 mills and has remained there ever since. But it is really more than 20 mills. The aggregate is made up as follows:

10.30 mills General taxes	$1,490,926.00
7.61 mills Int. & Sink. Fd	1,101,771.00
4.31 mills Schools	624,769.00
22.22 mills	$3,217,466.00

The gross result is therefore not 20, but 22.22 mills. A discount is allowed of 10 per cent if paid by December 15, but all who cannot pay at that date are taxed at 22.22, not 20 mills. How serious this is is shown by the total in the column of arrears at the close of each year. The arrears this year, I understand, are $767,528, as against $410,136.12 last year and $265,019.90 the year before. As the arrears have nearly doubled each year it is evident that the tax is felt to be extremely oppressive. A total of $767,528, or more than three-quarters of a million taxes this year, it appears paid 22.22 mills.

Perhaps the most loudly vaunted claim on behalf of the Vancouver system was that it caused an amount of building expansion and created an era of prosperity unparalleled anywhere on this continent. This triumphal blast has been heard the world over, and no doubt has created in some quarters a desire to follow in Vancouver's footsteps. On another occasion I pointed out that the great prosperity which we enjoyed arose from the same causes which were operating in every city in Canada. Our prosperity was part of the general prosperity, added to by our exceptional situation and equable climate. At the same time I recognized that exemption of buildings from taxation might have considerable effect in inducing a building boom, but could not be counted among the healthy causes of prosperity. So long as our building permits and bank clearings rose by leaps and bounds there were many ready to believe that all was owing to the magic of single tax. It only required a little financial pressure to show how absurd was the pretense and to bring us back to earth. From $13,150,365 in 1910, the building permits bounded up to $17,652,642 in 1911 and $19,388,322 in 1912. All and sundry were challenged to behold the results of "single tax magic." But single tax is still with us yet the building permits for 1913 have fallen to $10,424,448—nearly one-half. Worse than that the permits for December, 1912, were $1,530,365, and for December, 1913, $175,245. The aggregate for the year has been nearly cut in two, while the aggregate for the last month of this year is one-eighth of what it was for the same period last year. Bank clearings have also fallen, though not to a serious extent, and customs receipts have undergone a shrinkage. I point these things out, not with any view of depreciating Vancouver, but simply to establish the position previously taken, that the great causes of stability and progress or the reverse, are entirely independent of the nostrums of "single tax" advocates. To clinch the argument, if that is necessary, it may be pointed out that Winnipeg's building permits for eleven months this year amounted to $18,000,000 as against $15,106,450 for the full year in 1910, while her bank clearings exceeded those of last year by $97,159,713. Similarly Toronto's bank clearings this last year exceed those of 1912 by $11,000,000, and in Montreal the increase has been $34,648,000. None of these cities enjoyed the wonderful advantages of single tax,

While I admit that exemption from taxation of "improvements" has helped to create a building boom, I repeat that to the extent that this inflation has been caused by "single tax" it has been an unhealthy stimulus. I have before me figures showing the extent to which some of the most recent, as well as some of the oldest structures, are occupied, but say nothing with regard to them except that those who have been induced by exemption from taxation to rush up costly structures for which there are at present no adequate demand, have every reason to heap anything but blessings on the devoted heads of all "single tax" boomsters.

In conclusion let me call attention to the fact that the civic assessor has increased the land assessment from $144,974,525 in 1913 to $150,629,410 in 1914, an advance of $5,654,885. It is difficult to speculate as to the facts which justify this increase. Rents have decreased, in some cases very considerably. According to the assessor's own report our population has fallen off to some extent. Real estate is firmly held, but no one outside of the assessor's office will be foolish enough to claim that it has increased in value. At the same time the inability of owners to meet the taxes is becoming more marked each year. The total of arrears at the close of 1909 was $150,231.20; 1910, $179,296.74; 1911, $265,019.90; 1912, $410,136.12, and 1913, $767,528.00, nearly one-fourth of the entire tax levy for the year. It is only a question of time until there will be a general upheaval in Vancouver against this system of artificial and forced assessments of small property owners and householders to afford taxing the million-dollar sky-scrapers and apartment blocks, and against the foolish faddists who never cease in their endeavor to warp the mind of the laboring man into believing that this sort of thing is for his benefit. "Single tax," as we have it in Vancouver, is a boon to the rich and a burden on the shoulders of the poor. Its humbugging nostrums will not bear serious investigation. Besides being oppressive and unjust, it is useless for the purposes it is said to serve. It is high time to wipe out "single tax" and to return to honest methods.

Robert E. Smith, Roseburg, Oregon; Oregon Rational Tax Reform Association.

(Address before State Tax Conference, Seattle, May, 1914.)

I might say in the beginning that I am neither a tax expert nor a student of economics. I am a farmer.

I wish to call your attention to the fact that all of the remarks that have been made here today have been in regard to the conditions which apply to the city. Not a word has been said as to the merits or demerits of single tax as a taxing system for farm property. Single tax is a tax on land only. And the man who will be most affected by its adoption is he who has the most land. We all know that the farmer has the most land. It would seem, therefore, that if the students of taxation were honestly interested in the effects of the single tax they would first consider how it will affect the man who occupies and uses land for the gaining of his livelihood. Not being a student of political economy, I cannot speak accurately as to conditions at the present time, but when I went to the farm school we were taught that there should be three men in the country to one in the city. At that time that condition almost obtained. Although that was less than twenty years ago, conditions have changed very materially. While I have no definite figures, I know in a general way that now the majority of the population is in the city. There must be some reason for this great exodus from the farm and influx to the city. There must be some reason why our young men and young women do not care to stay on the farm.

To those of us who are identified with farm life the answer is not far to seek. It is not that there are better living conditions in the city. It is not that social conditions are of any higher order; neither is it the lure of the great "White Way." It is simply because the successful farmer of today must work from twelve to sixteen hours every day in the year, and when taxpaying time comes he donates the fruits of his year's labor to the state in the way of taxes. Do you blame our boys and girls for choosing to take their chances in the city rather than remaining on the farm when economic conditions are such as these? Granting the fact that it requires three men in the country to support the one man in the city, would it not be better to see how we can improve our farming conditions by the application of sound economic principles rather than aggravating the present instable conditions by the application of a freak socialistic theory which will make paupers of us all.

The reason that I was asked to speak here today is probably on account of my connection with an association known as the Oregon Rational Tax Reform Association. This is an association which was formed by farmers and is largely composed of farmers. It was formed because of an insistent belief among the farmers, which I believe to be correct, that under the general property tax as now administered the farmer is discriminated against. It was in order to have a little more justice in taxation and possibly to dodge some of our taxes—not our just taxes, but the unjust portion of our taxes—that this association was formed. We realized, however, that farm taxation only forms one part of the taxing system of the state, and if we were to improve the present system of farm taxation we must consider all phases of the entire taxing system of the state; that we should make an honest effort to construct a rational, fair and equitable system of taxation for all men and all classes of property. We were not and are not asking for special privileges, but for our just rights; not for favors but for fair play. We concede that in any question which so vitally affects all men, all men should be considered. We, therefore, made, and are making, an earnest study of city taxation as well as the taxation of rural property.

I made the statement last winter to a number of members of the association that I believed that there were certain good things in the single tax as applied to the city. It was all wrong as applied to the country, but possibly all right as applied to the city. These features of single tax which appealed to me as a fair system for municipal taxation were: First, that it promoted building; second, that it did not permit a man to have the value of his land enhanced through the enterprise and industry of another; and thirdly, it discouraged speculation in land. I said that when the opportunity presented itself I wished to make an investigation and get some first-hand information. I had a little spare time a few weeks ago and went to Alberta and made an investigation of conditions there.

Before discussing what I found, I want to go into this phase of single tax. There are two kinds of single tax. There is complete single tax, which is nothing more nor less than a form of socialism. That is to say, complete single tax has for its purpose the taking of all the income from land and giving it to the state. Now the value of anything is its capitalized income. When you take all of the income from property you are taking all of the capital or value. Therefore, complete single tax is communal ownership in land, or the destroying of private ownership in land. This phase of it I do not wish to discuss. I am sure that it is not necessary for me to argue against this phase of single tax. We have never considered it in Oregon. It has never been agitated here. The farmers of Oregon know that their land is good and they do not want to give it to the state. We want to keep it; it is good stuff—the best there is anywhere; we are proud to possess some of it.

Single tax limited is that system of taxation which raises public revenue from land alone—the land value tax—taking as much of the income from land as is necessary to run the government. The rest of the income the owner is permitted to keep. Complete single tax is not a system of taxation; it is a system of socialism. Single tax limited is advanced as a system of taxation and therefore we must consider it as such.

"The proof of the pudding is in the eating," and the best argument against single tax limited that can be used is the result which it brought about in Alberta. I honestly and confidently believe—yes, I positively know beyond the shadow of a doubt—that limited single tax as they have it in Alberta has been an absolute, complete, unqualified failure as a taxing system.

Although I have not the time to give you a detailed account as to the manner of raising public revenue in Alberta, in order that you may understand the difference between the raising of revenue there and on this side of the line I will say that in Alberta the money which the province of Alberta expends is nine million dollars annually. In the state of Oregon, with three times the population, we only raise seven million dollars annually. I do not mean to convey the impression that the public officials of Alberta waste her provincial funds, but that these funds are used for other purposes than we of Oregon use our state funds. The only tax levied on land in Alberta is a tax for municipal purposes. The revenue for the provincial government in all its branches, as well as the road and much of the school tax, is raised by indirect taxation, subsidy from the dominion government and license fees. To illustrate: In the state of Oregon the average tax levy in municipalities is about thirty mills. Of that thirty mills, six mills is for the purpose of running the city government; the other twenty-four mills is for state, county, school, roads and other purposes. In Alberta the tax for municipal purposes, that is to say, the tax which corresponds to the six mills tax just referred to, is raised by direct taxation and it is the only portion of their taxing system which is raised by a single tax upon land values. Therefore in Alberta they have what we might properly term a very limited form of single tax limited. Under what is known as the "towns act" the legislature foisted single tax on the small towns—that is, single tax for municipal purposes, you understand. The result was that a sufficient amount of revenue could not be raised. The functions of municipal government were paralyzed. That is the reason that single tax failed in Alberta. That is the reason that single tax will fail everywhere. Like other socialistic principles, it is beautiful in theory, but a pitiful failure in practice.

The reason for the failure of the limited form of single tax limited as adopted by Alberta is not hard to understand. If an uneducated Oregonian farmer like myself could discover the reason for this failure it surely should be apparent to such profound students of economics as our single tax friends.

In these little towns the land produces but little income. Most all of the income is produced from merchandise stocks and improvements on land. Even a farmer knows that if merchandise stocks and improvements on land produce much revenue they can afford to pay much taxes and if land produces little revenue it can afford to pay but little taxes. Even a farmer knows that when you come to exempt from taxation those classes of property which produce the biggest income, and place all the taxes upon that one class of property which produces the least income then something is going to pop. And, something popped in Alberta. You can take it from me that things were popping until they adopted a different system of taxation which relieved land from bearing all the burden of municipal public expense.

Now, let's see what was the first immediate effect. First, we find them putting up their assessed valuations higher and higher, in some cases placing them four or five times as high as the actual cash values of these lands. Next they reach out into the country and bring in the surrounding property and include it within the corporate limits of the various municipalities. Next we find that the land will not produce a sufficient revenue to pay the taxes and the taxes become delinquent and the land is confiscated by the state. Then we find that the municipal treasury is depleted. The city officers cannot be paid, no public improvements can be made, there is no fire protection and the municipal government is prostrated. Then we find them in the last stage changing their system of taxation and relieving land from bearing the whole of the burden of public expenditure. Now I do not wish to convey the impression that I found barefooted children upon the streets and babies crying for bread. The fact that I wish to bring out clearly is that so far as being a revenue-producing system, single tax has absolutely failed in Alberta.

The remarks which I have just made refer to the conditions as I found them in the small towns which are under the supervision of the bureau of municipalities. Now, let us look at the conditions of the larger towns which have special charters. Edmonton has almost a complete form of single tax for municipal purposes. It is a city of 57,000 inhabitants. I found that the land values there were $187,500,000. The land values of King County, including Seattle, are but $130,000,000. This shows that in order to raise their revenues it was necessary to place the land values at Edmonton at a figure far in excess of their true value. Think of it, a town of 57,000 population with assessed values of land of $187,500,000, while the assessed land values of all of King County are but $130,000,000. I found that the value of the land which this year is confiscated to the state for non-payment of taxes in Edmonton is $1,200,000. In all of King County the value of the land which reverts to the state this year through non-payment of taxes is less than $4,000. You understand I do not mean the value of the land upon which the taxes have been permitted to become delinquent in either case. In both cases I refer to the value of the land which has reverted to the state because the five years period of redemption has expired. Do you realize what these figures mean? In Alberta, a town of 57,000 thousand people, $1,200,000 worth of property is confiscated to the state this year, while in all of King County, including Seattle and smaller towns around the bay, there is less than $4,000 worth of property going back for non-payment of taxes.

In Calgary they have a milder form of single tax. There they tax personal property, that is, merchandise, stocks, etc., at 66²/₃ per cent of its value. They also tax improvements on land at 25 per cent of their value. Calgary is 50 per cent larger than Edmonton. We therefore would expect that the total of its land assessments would be 50 per cent greater than those of Edmonton. But are they? No! They are less. They are but $120,000,000. That is, $67,500,000 less than in their sister city of 50 per cent less population. And why? Simply because they have more kinds of property to tax. I also found in Calgary that less than one-third as much land had been confiscated to the state for non-payment of taxes. Therefore we find that the nearer we approach single tax the higher are the assessed valuations and the greater the amount of land which is confiscated to the state.

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VOLTAIRE ON SINGLE TAX

His Satire: "The Man With Forty Crowns," that Caused France to Repudiate Single Tax in the ~~Seventeenth~~ Century.

(Condensed translation from "Essays on Taxation," by E. R. A. Seligman, Columbia University.)

Voltaire pictured the position of the French peasant toiling laboriously, amid conditions of unspeakable distress, but succeeding in getting from the soil a product equivalent to forty crowns. The tax-gatherer comes along, finds that the peasant can manage to keep body and soul together on twenty crowns, and takes away the other twenty. Then the peasant meets an old acquaintance, originally poor, who has been left a fortune of 400,000 crowns a year in money and securities. He rolls along the highway in a six-horse chariot, with six lackeys, each with double the peasant's income; his maitre d'hotel gets 2,000 crowns salary and steals 20,000; his mistress costs 80,000 crowns a year. "You pay, of course, half your income, 200,000 crowns, to the state?" asked the peasant. "You are joking, my friend," answered he, "I am no landed proprietor like you. The tax-gatherer would be an imbecile to assess me; for everything I have comes ultimately from the land and somebody has paid the tax already. To make me pay would be intolerable, double taxation. Ta-ta, my friend; you just pay your single tax, enjoy in peace your clear income of twenty crowns; serve your country well, and come once in a while to take dinner with my lackey. Yes, yes, the single tax, it is a glorious thing!"

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MICHIGAN FARMERS' TAX GUIDE

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ECONOMICS SECTION

East Lansing, Michigan

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MICHIGAN FARMERS' TAX GUIDE

BY R. WAYNE NEWTON, RESEARCH ASSOCIATE

The levy and collection of taxes is entirely governed by law. The taxing officers of the State are required to levy taxes impartially and equally. However, their task is so great and so difficult that a certain amount of inequality is likely to result in spite of their best efforts. Because of this fact, the law provides means by which aggrieved taxpayers may protest against any seeming injustice.

The failure of many taxpayers to take advantage of this right is no doubt due in part to their lack of knowledge of the law. Yet failure to make a protest at the proper time places the responsibility for excessive taxation upon the taxpayer himself. The Supreme Court of Michigan has ruled upon this point, as follows:

> "Every owner of land is held to know the law. He knows that his land is subject to taxation; that he must pay his fair share of the public revenue and that if he fails to do so proceedings will be taken under the law against his land. It is his duty, therefore, to watch the proceedings provided for by the statute for the foreclosure of the lien and interpose any objections he may have to the validity of the tax."

The following pages have been prepared to serve as a guide to taxpayers, so that they may know their rights and privileges in regard to general taxation. The provisions of the law, as restated here, apply particularly to unincorporated places, and for this reason will be of greatest service to farmers and others living or owning property outside of cities and villages. The statement applies to cities and villages only in so far as the general or special laws or charters governing such places do not provide otherwise.

It should also be borne in mind that the full text of the law contains many provisions and clauses which do not have general application and which are not of such wide interest as to warrant their inclusion here. This statement is, therefore, a summary of the law and not a full and complete statement of it. The taxpayer who believes, after reading this publication, that he is entitled to take steps in regard to his assessment or taxes should consult with his attorney or with one of the following officials each of whom has been provided with a full copy of the General Tax Laws:

The township supervisor;
The township clerk;
The county clerk;
The county treasurer.

Taxpayers living in cities or villages may obtain information from city or village officials corresponding to those named for townships or from the county officials listed above.

Assessment of Real and Personal Property

Election of tax officers at annual township meeting.

A township supervisor and a member of the township board of review are elected at the annual township meeting, the first Monday in April. The township meeting is open to all qualified electors of the township.

Taxpayer to make a sworn statement of taxable property.

The township supervisor is also the township assessor, and immediately after his election he begins the assessment of property in his township. The assessor is required to obtain from each person of full age and sound mind a statement of all taxable property which he owns or holds for the use of another. The law requires that this information be given in the form of a sworn statement. If the person denies that he has any taxable property, the assessor is also required to obtain a statement under oath to this effect. The assessor, however, is not bound to rely entirely upon the sworn statement of the taxpayer. His duty is to assess to the best of his ability all property at its cash value. He may raise or lower the figures given him by the taxpayer if he thinks this necessary in order to show the cash value of the property reported. He may also add, whenever he finds it, property not given in by the taxpayer.

Certain kinds of property are exempt from taxation, by law. The following exemptions are available to properly qualified taxpayers:

Exemptions.

1. The real and personal property of persons who by reason of poverty are unable, in the opinion of the supervisor and board of review, to pay taxes may be exempted.
2. An exemption of $2,000 is allowed on the homesteads of veterans of the Spanish-American, Civil, or Mexican wars, or to the wives or widows of such veterans; but this provision does not apply in case the total amount of taxable property owned by the person has a value of over $5,000.
3. Each person is entitled to deduct his debts from the value of the amounts, in the form of bills, owed to him by others.
4. Household furniture, provisions, and fuel are exempt up to $500 for each household.
5. The working tools of a mechanic are exempt up to $100.
6. All mules, horses, and cattle not over one year old, and sheep and swine not over six months old are exempt.
7. Personal property owned by any householder and used in connection with his business is exempt up to a value of $200.
8. Bonds issued by any county, township, city, village, or school district within the State of Michigan are exempt.
9. Cut-over or wild lands which are purchased for the purpose of making a home are exempt, under certain conditions, from all taxes for five years if proper application is made to the supervisor at the time of assessment.

Private forest reserves.

In addition to these exemptions, owners of tracts of not over 160 acres of land of which at least one-half is improved and devoted to agricultural purposes may set aside under the provisions of the Woodlot Tax Act of 1917 as much as one-fourth of the total area as a private forest reserve. Owners desiring to take advantage of this provision must file papers with the county treasurer of the county where the land is located, and must comply with certain regulations as to planting and caring for trees, replanting when trees are cut, and restricting the use of the land for pasture. When the law has been complied with in these and other respects, the supervisor is authorized to exempt the private forest reserve from taxation except on a valuation of one dollar per acre. However, all timber, except firewood and building material for the use of the owner or his tenant, cut from a private forest reserve, is subject to a tax of five per cent of its value at the time of cutting. With the exceptions noted above, no timber is to be removed from the land until a return of the measurement or count, and the variety and the value of the trees cut has been made to the assessor.

Commercial forest reserves.

Commercial forest reserves may be established on certain cut-over lands which are chiefly valued for their ability to grow trees. Upon making application to the Department of Conservation and upon complying with the regulations established by that department, lands of this type may be approved as a commercial forest reserve. The taxation of such land is limited to an annual specific tax of five cents per acre on pine lands and ten cents per acre on hardwood lands. However, before merchantable forest products can be cut and removed from a commercial forest reserve, a permit to cut must be obtained from the Department of Conservation. The owner must pay a yield tax of 25 per cent of the value of the products of the reserve.

Board of review meets to correct assessment roll.

The assessment of property must be completed by the supervisor on the first Monday in June. On the following day, the township board of review which is composed of the supervisor and two other elected members meets to correct the assessment roll. *Any person may appear at this meeting and give information as to property omitted by the supervisor.*

Board of review hears complaints.

On the second Monday in June and on the day following, the township board of review meets at the office of the supervisor to hear and adjust complaints against the assessments made by the supervisor. *Any person affected by the assessment may appear to protest the assessment of his own or another's property.* If further action is to be taken on account of an assessment deemed unjust, it is necessary to protest before the local board of review at this time.

Review of assessment rolls by State Tax Department.

After the action of the board of review, and before the assessment rolls are turned over to the township treasurers for the collection of taxes, the rolls may be reviewed by one or more Commissioners of the State Tax Department or by a representative of that department. If, in the course of this examination *or through the written complaint of any taxpayer,* it appears that any taxable property has been omitted from the rolls or that individual assessments have not been made in compliance with the law, the State Tax Department may arrange for a hearing within the county on such doubtful assessments. Any assessment reviewed by one or more Commissioners of the State Tax Department must stand as approved by these officers for three years unless the State Tax Department gives written consent to a change before that date.

County board of supervisors equalizes assessments.

The county board of supervisors (township and city supervisors of the county) meets on the fourth Monday of June to equalize assessments of real and personal property as between the various townships, wards, and cities of the county. Any supervisor who believes that his district has been unjustly equalized is entitled to appeal to the State Tax Department from the action of the county board.

Equalization by the State Board of Equalization.

The final step in the assessment of general property is the action of the State Board of Equalization (Auditor General, Commissioner of Agriculture, and the three Commissioners of the State Tax Department). This board meets at Lansing on the third Monday in August. It is empowered to equalize assessments between the various counties of the State. After hearing the official representatives of the counties, and after reviewing evidence submitted by the State Tax Department as to the true value of all taxable property in the several counties, the Board of Equalization adds to or deducts from the assessed valuations of the counties such amounts as, in its judgment, will cause all property in the State to be equalized at cash value. The action of this board is final.

Levying Taxes

The annual tax paid on general property in Michigan goes to meet the costs of state, county, township, and school district governments. In cities and incorporated villages, there is an additional tax for the support of these municipal governments.

Township road taxes.

Township road taxes are voted by the electors of the township at the annual meeting the first Monday in April. Residents of incorporated villages included in the township may vote on road improvement taxes but not on road repair taxes. If the annual township meeting neglects or refuses to vote road improvement or repair taxes, the township board, acting with the road commissioner, is empowered to authorize such levies.

Additional township road funds.

When an emergency arises and it is the opinion of the highway commissioner that the road funds voted by the annual township meeting are insufficient, or when 15 or more land owners of the township sign a petition for more road funds, the commissioner and the township board, acting jointly, may vote additional funds, not exceeding $1,000, to be raised by township taxes. *If the additional sum needed is over $1,000, the matter must be submitted to an annual or special township meeting to be voted on by the electors.*

Township road bonds.

Upon the petition of 25 landowners, the township board may submit the question of a bond issue for road purposes to the voters at a township meeting or an election. However, bond issues for road purposes are limited to an amount equal to five per cent of the assessed valuation of the township, and *the bonds much receive a majority vote to carry.*

Township general levies.

Taxes to meet the ordinary expenses of the township may be voted at a township meeting, but the township board is empowered to vote any necessary taxes for ordinary expense which the township meetings do not vote. The board is also authorized to vote taxes, without the action of the voters, to meet any obligations such as court orders, bond interest, or principal, which accrue against the township.

School district levies.

The annual meetings of the school districts are held on the second Monday in June or on the second Monday in July, the date varying by districts. *Certain school taxes may be voted at this or any special meeting of the school district called for the purpose.* Only citizens of the United States who are 21 years of age and who are residents and taxpayers in the district can vote on school district taxes at these meetings. Taxes may be voted at these meetings for the purchase, building, or hiring of a school house, and for other purposes not otherwise provided for by law. School bonds may also be voted at school district meetings. The district school board, elected at the annual meeting, has authority to vote taxes necessary to pay the running expenses of the school. These expenses are school furnishings, teachers' salaries, transportation of pupils, and similar items.

State tax levies.

On or before Sept. 1 of each year, the Auditor General determines, from the various statutes and acts of the legislature which require the levy of state taxes on general property, the amount of state taxes to be raised for the year. He apportions these taxes between the counties on the basis of the valuation of each as fixed by the State Board of Equalization in August. The Auditor General reports to the county clerks the amount of state taxes apportioned to each county. This report is made before the date of the October meeting of the county boards of supervisors. The Auditor General also reports at this time the amount of any debt which the county may owe to the state, which is to be met by county taxes unless otherwise paid by October 1.

County tax levies.

On the second Monday of October, the county board of supervisors meets to determine the amount of county taxes to be levied. These levies are used to pay county officers, to meet county debts and judgments against the county, to pay for road building and repairs, and for certain other purposes.

The board of supervisors in counties with an assessed valuation of $10,000,000 or over cannot borrow or raise by taxation more than the proceeds of a tax of one-tenth of one mill in any one year for constructing or repairing public buildings or bridges, unless authorized to do so by the voters at an election. The board of supervisors in counties where the assessed valuation is less than $10,000,000 may levy or borrow not over $1,000 for the above named purposes, annually, and any additional amounts which the voters may approve by a majority vote.

Apportionment of State and county taxes among townships. The board of supervisors also apportions state and county taxes among the townships according to the assessed valuation of each as determined by the board at its June meeting, or as determined by the later review by the Commissioners of the State Tax Department.

Hearing on township levies. At the same meeting, proposed township, school, road, drain, and other tax levies are reviewed by the county board of supervisors. *An opportunity is given for a hearing of objections against these levies on the part of persons affected.*

Supervisor prepares tax roll. After the October meeting of the county board of supervisors, the township supervisor apportions the township, county, and state taxes payable in his township according to the assessment made by the township board of review in June, and prepares the township tax roll.

The Collection of Taxes

Collections, Dec. 1 to Jan. 10. The collection of state, county, and township taxes begins the first day of December. The township treasurer is required by law to be in his office from 9:00 a. m. to 5:00 p. m. every Friday in December to receive taxes, but he is authorized to receive them on any other week day on which they may be offered. A collection fee of one per cent is added to the tax bill from December 1 to January 9, inclusive.

Collections, Jan. 10 to March 1. On January 10, the collection fee on all taxes not yet paid is increased to four per cent. After this date, the township treasurer is required to make a demand in person upon all property owners living in the township for the taxes due. Upon their refusal to pay, the treasurer is authorized to seize and sell their personal property in sufficient amount to pay the taxes. An additional charge of $1.50 for sale expenses may be imposed when a sale is made. If unable otherwise to collect for personal taxes, the treasurer may sue for the taxes, and collect from persons owing debts to the delinquent taxpayer.

When tenants may pay. A renter of real estate may pay the taxes on the rented property and deduct the amount paid from his rent unless he has previously agreed not to do this.

Lands deeded to State for taxes. Taxes assessed on land will be dropped if the land is deeded to the state free of all incumbrances within 10 days after the seizure for taxes of the personal property of the owner.

Collections after March 1. The township treasurer continues to collect taxes on personal property throughout the year, but real estate taxes which are paid after March 1 must be paid to the county treasurer. In addition to the four per cent collection fee previously imposed, persons paying real estate taxes after March 1 must also pay an interest charge of three-fourths of one per cent per month or part of a month from March 1 until the date of payment. A further charge of one dollar is added on all descriptions of land on which taxes remain unpaid on October 1, one year and 10 months after the tax was first payable.

Sale and Redemption of Real Estate Delinquent for Taxes

Circuit court hearing on tax sale petition.

Whenever land has been delinquent for taxes for two years or longer, it is liable to be sold for taxes. Owners of delinquent land usually will be sent written notice of the proposed sale at least 30 days in advance. Before such a sale takes place, it is also necessary that a hearing be had in the circuit court of the county in which the land is located. Notice of this hearing will be published in one newspaper of the county at least once a week for four successive weeks before the hearing. Owners may appear at these hearings and protest against the legality of the tax which was assessed against their property.

Appeal to Supreme Court.

If the owner appears in court and protests the legality of the taxes remaining unpaid and the court rules against his claim, he may appeal to the Supreme Court upon depositing with the county treasurer within 10 days after the hearing the amount decreed against his land by the lower court. If the taxpayer receives a favorable decision from the Supreme Court, the full amount so deposited will be returned to him. If the decree of the circuit court is in favor of the taxpayer, either the county treasurer or the Auditor General may appeal to the Supreme Court.

When lands of minors and insane persons may be withheld from sale.

The circuit court may withhold from sale any lands which are shown to be the property of minors or insane persons who are without legal guardians. Action on such lands may be postponed until legal guardians can be appointed. Even where the sale has already taken place, the court has authority to cancel such sale when it is shown that such incompetent owners were without legal guardians at the time of the sale.

Sale of land for taxes.

Lands approved by the circuit court to be sold for taxes are sold by the county treasurer on the first Tuesday in May. The sale begins at 10:00 a. m. and continues daily, except for Sundays and legal holidays, until each description of delinquent lands has been offered twice. If the land cannot be sold for enough to pay all taxes and charges against it at the second offering, it is bid in for the state.

Purchase after tax sale.

At any time after the annual tax sale is closed, any lands bid off to the state can be purchased from the Auditor General for the amount of the taxes and charges against the land at the time of sale plus interest at one per cent per month or fraction of a month from the date of the sale until the date of such purchase.

Redemption of lands sold for taxes.

The former owner of lands which have been sold for taxes may redeem such land at any time before the first Tuesday in May in the year following the sale. To do this the former owner must pay the county treasurer or the Auditor General the total amount of the charges against the land at the time of sale, plus interest at one per cent per month or fraction of a month from the time of sale until the date of the redemption.

Michigan Farm Tax Calendar

JANUARY

January 1-9, inclusive. Taxes receivable by township treasurer with one per cent collection fee.

January 10. Tax collection fee increases from one per cent to four per cent. Township treasurer begins making personal demands for unpaid taxes. Township treasurer authorized to seize and sell personal property for all taxes on refusal of demand for taxes.

FEBRUARY

Personal demands for taxes and sales of personal property for taxes by township treasurer continue throughout the month.

MARCH

First Tuesday. Regular meeting of the Commissioners of the State Tax Department.

Real estate taxes payable to the county treasurer with added interest at the rate of ¾ of one per cent per month or part of month from March 1.

Township treasurer continues the collection of personal taxes.

APRIL

First Monday. Annual township meeting. Township appropriations, road taxes, and bond issues are voted. Township supervisor, (assessor), and one other member of the township board of review are elected.

Supervisor begins the annual assessment of real and personal property.

Notices of proposed tax sales of real estate mailed to owners.

Watch papers for notices of hearings on tax sales of real estate.

County treasurer continues to receive taxes and interest due on real estate.

MAY

First Tuesday. Beginning of sale of real estate delinquent for taxes for two years or more. Sale conducted by county treasurer.

Township supervisor continues the assessment of real and personal property.

JUNE

First Monday. Township supervisor completes assessment roll.

Tuesday following first Monday. Township board of review meets to correct assessment roll.

First Tuesday. Regular meeting of the Commissioners of the State Tax Department.

Second Monday. Annual meetings of school districts at which certain school district taxes are voted. (In some districts this meeting is the second Monday in July.)

Second Monday and following Tuesday. Township board of review meets to hear and adjust complaints of taxpayers against the assessment roll. *Any taxpayer may make a written protest to the State Tax Department, complaining of assessments made by the township board of review.*

Fourth Monday. County board of supervisors meets to equalize assessments between townships, wards, and cities.

JULY

First Tuesday. Regular meeting of the Commissioners of the State Tax Department.

Second Monday. Annual meetings of school districts at which certain school district taxes are voted.

Commissioners of State Tax Department visit counties to review assessment rolls and investigate complaints against assessments.

AUGUST

First Tuesday. Regular meeting of the Commissioners of the State Tax Department.

Third Monday. State Board of Equalization, (Auditor General, Commissioner of Agriculture, and the three Tax Commissioners), equalizes assessed valuations between counties by increasing or decreasing the total valuation of real and personal property.

Commissioners of State Tax Department continue visiting the counties.

SEPTEMBER

September 1. Auditor General determines the amount of State taxes on or before this date. Apportions the tax among counties before the second Monday in October.

First Tuesday. Regular meeting of the Commissioners of the State Tax Department.

Commissioners of the State Tax Department continue visiting the counties.

OCTOBER

October 1. A State charge of one dollar is added to penalties on real estate delinquent for one year and ten months.

First Tuesday. A regular meeting of the Commissioners of the State Tax Department.

Second Monday. County board of supervisors hears objections of taxpayers to proposed township appropriations and levies. Board fixes township levies and apportions state and county taxes among township, wards, and cities.

Commissioners of the State Tax Department continue visiting counties.

NOVEMBER

Township supervisors prepare tax rolls in this month.

Prepare to pay annual taxes in December or early in January and avoid increased collection fee.

DECEMBER

Tax collection begins December 1. Township treasurer's office open from 9:00 a. m. to 5:00 p. m. every Friday in December, but taxes may be received on any other week day not a legal holiday.

The TAX DIGEST

VOLUME 3

NUMBER 5

NOVEMBER 1926

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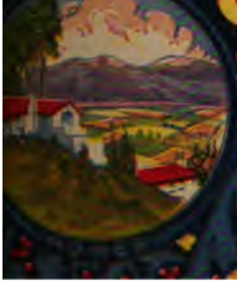

Published Monthly by the
California
Taxpayers' Association

CITY AND COUNTY COMMITTEES

OF

California Taxpayers' Association

Kern County Committee

Dr. Geo. C. Sabichi, Bakersfield, Chairman; James Egan, Bakersfield, Secretary.

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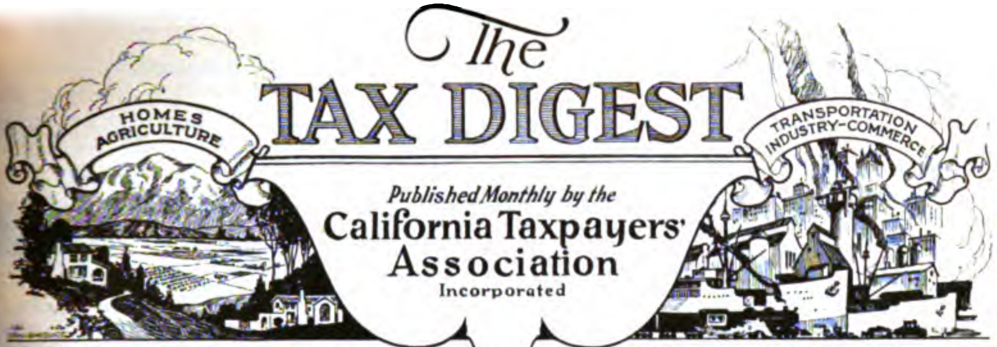

The
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Taxpayers of Twelve Western States Meet in Fourth Annual Conference

OPENING THE CONFERENCE, OCT. 11, IN LOS ANGELES

Representing 15,000,000 of population in the twelve commonwealths of the great West; approximately $50,000,000,000 of property values; between $1,000,000,000 and $2,000,000,000 of annual governmental costs, and the taxpayers of all classes, railway corporations, insurance companies, public utility concerns, merchants, manufacturers, and other large tax-burden bearers, *and especially the multitude of small taxpayers, the four million families of this great western empire*, the fourth annual Western States Taxpayers' Conference met in Los Angeles, Oct. 11, 12 and 13 at the Biltmore Hotel. California Taxpayers' Association and the Los Angeles Chamber of Commerce were jointly the hosts. The Conference was a serious, earnest, industrious body of men and women. There was no junketing, or pleasure trips. Not even the breakfast hour was omitted from the program of work, so that from eight o'clock in the morning until late at night, these days were devoted to intensive discussion of taxation and devising of methods whereby the rapidly increasing tax burden may be lightened. Matter of such transcendent importance was under consideration, that The Tax Digest will not print it all in this issue. All papers and reports will, however, be given in subsequent numbers of The Tax Digest.

until the whole story shall have been told in the form of a serial.

The Conference Opens

At two o'clock on Monday, Oct. 11, the Conference was opened by Dr. Milbank Johnson, the president, who is also chairman of the Board, California Taxpayers' Association.

He introduced A. C. Hardison, president of California Taxpayers' Association, who delivered the welcoming address, pointing out the danger of abuse of the taxing power of government. While Mr. Hardison was expressing the cordial hospitality of California, a telegram came from President Coolidge, in which the Chief Executive said: "I am sorry I cannot attend the meeting of the Western States Taxpayers' Conference. Please extend to those present my greetings and best wishes for the success of your deliberations."

A little later a telegram came from United States Senator Reed Smoot of Utah, chairman of the Finance Committee of the Senate, which read. "Please convey my regrets that I cannot join the Western States Taxpayers' Conference. The object of the meeting meets my hearty approval, and I hope that increase of taxes, economy in expenditure of taxes collected, and simplification of tax laws will be stressed."

The Conference proceeded immediately to the program, the first paper being by Prof. M. M. Stockwell of the Department of Economics, University of California in Los Angeles, on "The Relation of Federal, State and Local Taxation."

After Charles R. Hows, tax commissioner of Arizona, had been introduced to the Conference, Judge Henry H. Rolapp, Vice-President of the Western States Taxpayers' Conference, and President of the Utah Taxpayers' Association, gave in detail the history of the formation of the Conference.

Some State Progress Reports

The Chairman, after appointing the committees, called on C. C. Chapman, editor of the Oregon Voter, and the member for Oregon of the Advisory Committee, who reported progress in his state during the past year. F. N. Fletcher of Nevada followed with a progress report, after which Judge Rolapp reported for Utah that every county in the state had been organized by the State Taxpayers' Association. Rupert F. Asplund reported for New Mexico; A. G. MacKenzie for C. E. Arney, Jr., for the State of Washington; Vance H. Evans for California; E. M. Sawyer for Idaho. These reports will be epitomized in later numbers.

Monday Dinner Session

Not even the dinner hours were wasted. At half past six o'clock, with Dr. Johnson as toastmaster, the delegates carried on the discussion around the dinner table.

Mr. Hardison emphasized the vital interest of agriculture in tax matters.

M. D. Lack, Vice Chairman and Tax Counsellor, California Taxpayers' Association, discussed "The Organization and Functions of Local Committees."

A. E. Poulsen, president of the Sonoma County local committee, told of the research report of California Taxpayers' Association in the affairs of his county. James Egan, secretary of Kern County Committee, reviewed the work that has been done there.

Charles L. Wright, president of the Pasadena local committee, gave an interesting account of the work in that city, especially referring to the Holly Street Improvement, after which Joy A. Winans, chairman of the Los Angeles City Committee, spoke, making special reference to the Los Angeles Flood Control District affairs, and announcing that the directors of the Los Angeles City Committee had resolved to oppose the $26,000,000 flood control bond issue on the Nov. 2 ballot until there should have been more detailed information relating thereto.

The dinner session closed with an interesting statement by George G. Tunnell of Chicago.

Tuesday Activities

The delegates were at their work again Tuesday morning, Oct. 12, at eight o'clock at the breakfast table and at ten took up the regular session in the Conference Hall. The Chairman called on H. M. Richter, delegate from Texas, to report on the taxation affairs of that commonwealth, after which Marshall DeMotte of Corning, Cal., was introduced to speak on "The Relationship Between Fixed Charges, Initiative and Legislative, and Administrative Costs of Government." DeMotte was former chairman of the State Board of Control of California. Discussion followed, led by Mr. Newell of Pasadena.

Vicissitudes of Building a Great University

The paper by Dr. Henry Suzzallo, President, University of Washington, was read to the Conference by Dr. Frank C. Touton, Professor of Education, University of Southern California.

The Chairman stated:

A few days before the Conference opened the Board of Regents of the University of Washington asked Dr. Suzzallo's resignation. The Board of Regents had only lately been reconstituted, by Gov. Hartley, so as to give a majority of members who would support the Governor against Dr. Suzzallo. The controversy had arisen during the World War, when Dr. Suzzallo, as chairman of the Industrial Relations Committee for the state, had brought an eight-hour day into the lumber camps of Washington. Gov. Hartley, who is a lumberman, bitterly opposed Dr. Suzzallo's eight-hour day for the lumber camps.

There were two other angles to the controversy. The University of Washington owns ten acres of the old campus which had been leased for 50 years to various business interests, and on which business structures had been erected by the lessees, the structures to revert to the University at the expiration of the leases.

Under the terms of the leases, the University derived only about $80,000 annually in ground rentals. The land has increased enormously in value since the leases were made, being now worth many millions of dollars. Dr. Suzzallo saw in this ten acres in the heart of Seattle an asset which, preserved and treated according to the ordinary rules of business, would in time make the University self-sustaining.

Pressure was brought to bear on Dr. Suzzallo to renew the leases on the old terms of rental. Dr. Suzzallo refused, and was supported by the Board of Regents.

Gov. Hartley appointed enough new Regents to give him a majority, and Dr. Suzzallo's resignation was requested.

The other angle to the controversy was: The University owns a large tract of timber which came into its possession as a land grant from the United States.

This timber land is in one body where it has been inaccessible because of lack of transport facilities. It has therefore been of relatively low market value. However, the increasing scarcity of timber has brought the University timber lands into demand, and pressure has been brought to bear on Dr. Suzzallo to sell the lands. He and the Regents refused on the ground that the lands would still further increase in value, and the University largely profit by holding them.

The lumbermen insisted. Dr. Suzzallo was adamantine on both proposals, taking the ground that the patrimony of the University was involved, and that it was his duty and the duty of the Regents and of all friends of education and of the friends of the taxpayers of the state to protect the University property.

The controversy, therefore, had detained Dr. Suzzallo in Seattle, and Dr. Touton read Dr. Suzzallo's paper which had come by airmail.

A DOLLAR'S WORTH OF EDUCATION

By DR. HENRY SUZZALLO

President, University of Washington

In these days when tax burdens are greatly increasing, it is natural that attention should be focussed upon the largest item—education. It is always the largest item that seems to offer the largest possibility of a cut, though this by no means follows. It may be spent far more effectively than many smaller items. That is a fact to be determined. It will be determined, not by prejudice, but by judicial examination.

Some Tax Associations, notably the one in California, are doing just the type of work that educationalists and taxpayers and other kinds of Americans appreciate. It is not trying to dictate American policy, or to change the fundamental American traditions, which insure free government through the fostering of intelligence. It is merely inquiring into the administration of school funds and asking if the money is well spent.

There are other leagues of taxpayers which exercise no such restraint, and are more propagandistic than judicial. They are willing to wreck the school system and American democratic institutions, provided they can save a few dollars. Such efforts are futile. They can have no permanent success. They stir animosities which are slow to heal. They separate themselves in the name of economy from the schoolmasters who are striving for efficiency, when it is plain to everybody that the forces for efficiency and economy must co-operate, if the public is to get what it needs at the lowest reasonable cost.

I take it that this tax conference is not interested in a saving of school money which would change the fundamental nature of our American institutions and our national life. Our political forebears have determined that there shall be equality of opportunity for our youth to develop its human capacities through schooling. You are not interested in the tax reducer who says that there can be too many educated and intelligent men and women; or in the fellow who fears there will be a short labor supply of the ignorant and docile kind, if schooling is too freely supplied. You want schooling, but you wish your dollar's worth of education.

A Dollar's Worth of Nails

How is a dollar's worth of education to be determined? In the same way that you know whether or not you are getting a dollar's worth of nails. It is strange how many fail to see the fundamental likeness, and go astray in their thinking. They think that they ought to get a perfect human product from the schools at any price they feel comfortable in paying. That economic version is not true anywhere in business where men ask and pay a price. Quality and quantity go up or down as the price paid varies. This is just as true in schooling as it is in any economic service. Hold fast to this thought and many fallacies in thinking about school expenses will disappear.

DR. HENRY SUZZALLO

A dollar's worth of nails today is different from a dollar's worth several decades ago. Science and industrial progress have improved quality and quantity in production. You may need more or less of a thing, or a better kind. The dollar is not the same dollar. Its purchasing power has changed. All these factors have to be kept in mind in school costs, yet they are not. Educational science and psychology can now give us a better educational product than before, and we want it. Our standard of living has raised here as elsewhere. It is the privilege of a democratic people to have better schools, just as it is theirs to prefer an automobile to a horse and wagon.

A Moral Problem

The problem of getting people to want something else than they do is another problem. Perhaps they have the wrong values and are spending too much money in one place. But this is a problem in the moral, social and spiritual reconstruction of men and women. It is not a problem in economics. They may be spending more than their income. This is serious, but it is primarily a question of morality, though it has terrific economic effects.

The only way to know whether you are getting your dollar's worth in education is by comparative study. What is the other fellow getting for his dollar? How does he educate more people in a better way by spending less money? What is his method of administration? How is spending organized? What is the training of the spenders? How far, finally, may we apply his methods to our differing conditions? The last question will keep us sane.

There are two domains in which we may watch the uses of a dollar. The first is in the domain of administration, and the second in the domain of teaching. We are more at home in the first field than in the second. Here is where taxpayers' associations have done their chief work. Locating schools, building and bonding, purchasing supplies, hiring and distributing teachers have been the chief factors taken into account. Improving the effectiveness in turning out more and better human product is still a mysterious field to the layman, but the educationalist is beginning to understand it through the new science in education. Taxpayers must be concerned with it.

In the field of administration there are certain obvious comparisons of methods which give aid.

We can give education cheaper and better through the consolidation of schools and the transportation of pupils, through sending students to another school district with one district paying another, where these devices are applicable to the particular case.

Larger Units

Larger units of school management than the little country district will help. County or community units of management may be given some larger use than now, without destroying local self-government, an essential feature in American life not to be lightly put aside.

There is no more delicate problem than to determine which school functions shall be centralized and which decentralized. Only experience will tell what is right. The present passion for centralizing everything to get financial efficiency is dangerous. It is stressing consideration of one factor and losing sight of others.

You may save money and get a centralized and standardized bureaucracy, inject politics into your schools and make them easy victims of propaganda. The representative of a new league of taxpayers' associations in one state proposes that all the schools be under control of one central state board and that all teachers be appointed by this board of laymen with professional advice. Such a board might well determine minimum standards of training and certification, but the hiring of teachers should be left with some authority nearer the parents of the children they teach. Anglo-Saxon civilization, of which America is a part, is more broadly common sensed by its experience than it is narrowly and relentlessly logical in pursuing a single object.

The locating of different types of schools may, in these days of local pride, be a great source of waste. Four years of high school may be maintained where there should be only two years. Junior colleges may be maintained at home where the expense would be less than if students are sent away. Large units of management on the higher ranges of schooling make for economy. Fortunately the new articulations of the school system will aid local adjustment. Where once we had just elementary schools, high schools and colleges, we now have respectable and effective units including elementary schools of six years, junior high schools of three years, senior high schools of three years, and junior colleges of two years. Meager attendance is sometimes unavoidable. When it is, we must pay the bill. But it is more often avoidable, with modern transportation, to saturate a school unit to the point of high working efficiency and economy; that is, to a thrifty point of organization.

Central Purchasing

Central purchasing instead of district purchasing is an advantage clearly demonstrated by every study made. One specialized office can do better than eighty school boards of laymen who do not make buying a major business. But experience opposes the purchasing for a school system being merged with a bureau of the general political government. School systems should be given a certain autonomy, like the courts. Their immense budgets are a constant temptation to politicians who would use their buying and hiring as patronage. We have largely fought our way to independence of politics. Why retreat to ancient evils of which we are largely rid?

Careful budgetting is of high advantage. But the budget officer who recommends cuts and reductions should be more than an accountant dealing with figures representing dollars. He should know something about function. All efficiency is related to educational function. In many cases the budgetting political officer is hopelessly ignorant. The budget is a splendid tool in the hands of a competent mind, and a stupid instrument when it is not. Budget forms must be made up with more regard for interpreting tasks to be performed than is the case at present.

In the domain of teaching we have just begun to study economy and efficiency in a scientific manner. This is a wholly psychological problem which the ordinary layman does not and probably will not understand. Here reliance on the professional expert must be had. Segregation, and different speed of mastery among groups of pupils is an economy. The bright will go faster and save school years. The slower will move ahead at their own pace without tripping and charging repeated years to the taxpayer.

Another illustration is provided in the lay opposition to supervisors. Good supervisors of ordinary teachers double the effective service of the teachers under them. It is all a matter of when and where and how they are used. a problem in educational adjustment. On the budget they look like extra help and are readily lopped off. Better increase the size of classes and provide good supervision than do without it.

"Trimmings"

Another fallacy is the talk about "trimmings, fads and frills" in the course of study. With so many kinds of human nature to be served, what is a frill to one student is a need to another. The chief reason these subjects have not been eliminated is because the different parents could not agree. Therefore it is left to the schoolmasters where it may better be left. The science of their own profession will take care of the matter.

There is another economy fallacy that lurks in this field. To maintain some of these modern subjects does not add their total budget cost to the taxpayer. The child has to be taught something. If it is not one subject, it is another. You merely add the differential in cost if there is one, not the whole budgetary amount.

If a student making progress in a subject that costs ten per cent more is compelled to take a subject of lower cost where he makes no progress and has had to repeat, the state loses ten-tenths where the thought was to save one-tenth.

Money expenditure is related to performance of function. America as compared with other industrial countries has a much heavier capitalization, but it pays higher wages and gets a mass production that lowers prices. There is a thought there for educational production.

Educational research and new scientific procedure promise most for efficiency and economy in the domain of teaching. The intelligence tests as aids to diagnosis, standard achievement tests, the new comprehensive examinations, comparative study of teaching processes all promise to give the taxpayer more for his dollar in school, just as science and scientific technology have given more and better nails for a dollar than before.

Three Addresses

Charles A. Rudel, tax expert, Pacific-Southwest Trust & Savings Bank, then read a paper on "Analyzing Bond Proposals."

Prof. Rolland A Vandegrift's paper on "Costs and Methods of Financing Public Improvements" followed.

COSTS AND METHODS OF FINANCING PUBLIC IMPROVEMENTS

By ROLLAND A VANDERGRIFT

Director of Research, California Taxpayers' Association

Montesquieu, the French philosopher, as early as the eighteenth century made the observation that liberty invariably increases taxes. The in- great thinker gave expression to this thought, has demonstrated the truth of the statement.

The increase of taxes has been necessary be-ment largely due to an expansion of the functions of government. Under the monarchies and other forms of personal rule, the bulk of expenditures went to support the person of the ruler and his establishment.

The public treasury was, in effect, his personal purse, and was used to gratify his pleasure or extend his power. The demands were almost limitless and imposed a burden only in itself limited by the physical ability of the subjects to contribute, or the power of the ruler to extract, without destroying the source of revenue.

The use of public funds, primarily for the benefit of the ruling class, and the obnoxious methods of the royal tax collectors in imposing taxes which took from the producer a larger and larger share of his earnings, finally resulted in revolutions which overthrew the absolute governments.

These revolutions were not necessarily brought about by the monarch's impoverishing the nation, but because the expenditures were made in the interests of the ruling minority. The taxpayers, who were now developing learning, could not see that they were getting a return from the heavy exactions. The revolt and the establishment of popular or representative government brought, as a matter of course, the condition that public disbursement should be for the general benefit rather than for the few.

It was but natural that once the people enjoyed public service at the expense of the general treasury there should be an indefinitely expansive demand for such service to satisfy them. As a result, expenditures began to expand, until the former outlay of monarchies became insignificant in comparison. The people, now, through the vote, encouraged too frequently by the tax spenders, make expenditures.

At the same time, as popular government expands, public activities multiply both in extent and number. Old functions are extended to embrace more, and new functions are taken over.

Public expenditures have, as a consequence, increased faster than population and wealth. The danger, however, does not lie in the amount of taxes, so much as whether expenditures are wise, proper functions of government, and are being efficiently and economically administered in the interests of all the people of the community.

The demonstration that "liberty invariably increases taxes" is more emphatically seen in the United States than in any other country. The functions and activities of government here have expanded to almost countless numbers, all presumably in response to public demands, and all of which, under the immutable law of compensation, must be paid for out of the pockets of the taxpayers.

Federal, state, county and municipal governments all carry on activities, the lists of which are almost limitless and which frequently overlap and duplicate. Many of these activities contribute to the benefit of the general public, and others apparently only assist a special group and indirectly the public interest.

The constantly increasing taxation and expanding of public expenditures in all these divisions of government are largely the results of ever expanding intensively and extensively of the services and activities performed. It is undesirable to eliminate entirely or unnecessarily restrict these services in an expanding society, but there is a pressing need that constant vigilance be exercised to prevent expenditures from expanding beyond ability to pay. Therefore, accurate information of the growth in extent and cost, nature and spread of benefit, and constant guard for their wise, economical and efficient administration are needed, so that the fullest return can be made for the tax burden imposed.

SOME FACTS

According to figures prepared by the National Industrial Conference Board and carried to the year 1925, the latest available, the total volume of taxation collected in the United States in 1924 was $7,907,000,000, compared with $7,766,000,000 in 1923, and $2,194,000,000 in 1913. The increase of $141,000,000 in 1924 was 2 per cent over 1923. and the total was more than three and one-half times as large as in 1913.

The per capita total for 1924 was $70.99, compared with $70.21 in 1923, and $22.73 in 1913.

The average burden per person gainfully employed was $182.94 in 1924, $184.05 in 1923, and $59.25 in 1913.

Per family, the total taxes amounted to $304.23 in 1924, against $303.58 for 1923, and $102.12 for 1913.

There is no mistaking the effect of such an increase of the tax burden. It cannot continue at such a rate and our prosperity endure. Happily there appears to be a realization of the dangers and an intelligent move to find a remedy, the Federal Government pointing the way in repeated tax reductions and internal economies. Even now. only a few months after the last Federal tax reduction, we are looking forward to another possible reduction by the next Congress.

The Federal Government collected $3,095,000,000 in 1924, compared with $3,220,000,000 in 1923, a decrease of 3.9 per cent, but the states took up all but $6,000,000 of this savings by increasing taxes from $945,000,000 in 1923 to $1,064,000,000 in 1924, an increase of 12.6 per cent.

Local governments increased their taxes by 4.1 per cent, or from $3,601,000,000 in 1923 to $3,748,000,000 for 1924. The Federal Government took in 1924 approximately 40 per cent and local governments 60 per cent of the total tax bill collected.

Reducing the situation to terms of the 1913 dollar, so as to take into consideration the decrease in the purchasing power of the dollar, the total tax bill in 1924 was almost two and one-half times as high as in 1913.

WHEN BONDS ENTER THE EQUATION

Much more was expended by all governments in the years noted than was raised in taxes. Total expenditures, as given by the National Industrial Conference Board for 1924, amounted to $10,252,000,000, compared with $10,145,000,000 in 1923, and $2,919,000,000 in 1913. This is an expenditure for 1924 of about three and one-half times the 1913 figure. This was in spite of a 10.6 per cent decrease in the cost of the Federal Government for 1924 under 1923, and was due to the fact that expenditures by state governments increased $225,000,000 and local governments $267,000,000.

In terms of 1913 dollars, Federal expenditures in 1924 were more than three times as high as in 1913; state expenditures about two and three-fourths, and local governments a little less than twice as high.

Less than one-third (31.8 per cent) of the total expenditures were made by the Federal Government, (68.2 per cent) or over two-thirds were spent by local governments.

The greater part of expenditures above taxes collected is represented in borrowed money which must be paid back with interest, and therefore, establishing a fixed tax burden for this purpose until the debt is retired. Borrowing by honest governments which do not repudiate debts is merely postponed taxation, and eventually must be paid by the taxpayers.

TIME TO CALL A HALT

This increase in public expenditures cannot continue indefinitely. The people of the United States as a whole, and in particular citizens of the western states, are fast approaching the time when, through necessity, they must determine carefully how much of the income of the people may be taken for public expenditure, without lowering the individual standard of living.

Approximately one-sixth of the total annual income of the people of the United States is taken now for governmental expenditures. There is grave doubt if a much greater proportion may safely be taken without disturbing the very ideals which we call American. Already we are informed that the increase of population indicates that, at a not remote date, the pressure of population will force down our scale of living, unless we can keep it up through greater efficiency in industrial production.

As far back as 1890 it was stated by the Bureau of the Census that the American Frontier in the United States had disappeared, and that there was virtually no more desirable free land to be had. Since that date there has been a remarkable increase in population and an industrial development unequalled anywhere in the history of the world. Through industry and *the use of our natural resources*, we have pressed forward. The increasing services demanded by the people of government have been provided. Our tax burden has grown in proportion and with acceleration since 1913.

The older state and local governments in the East made extensive capital outlays for public improvements while there was free land for expansion and exploitation, and an abundance of natural resources to draw from. The newer states and their political subdivisions in the West have much of their capital outlay for public improvements to make, and conditions of financing are much changed over what they were even fifty years ago. Although most of the government land open to entry lies in the western states, there is comparatively little valuable free land, and the natural resources, although abundant, are by no means untouched. In some of the western communities it is already more difficult to pay for public improvements than it was when local natural resources, now practically exhausted, were being exploited.

It is the part of wisdom to be prepared and see how we can continue to provide the greatest measure of public service without increasing the tax burden out of proportion to benefits, and in particular we should prepare to provide those services which are most essential.

PUBLIC IMPROVEMENTS

Undoubtedly, the greatest single factor in the increased cost of government and one of the most difficult problems to solve is the financing of public improvements. The aggregate costs of public improvements have steadily grown from year to year, until now they reach an appalling figure annually. No accurate analysis has been prepared and it is doubtful if such can be made for the annual expenditures for all public improvements, because of the variety of methods used in financing, and overlapping with other functions of government.

The activity of the Federal Government in financing public improvements will not be included in this discussion and attention will be directed to municipal public improvements. Municipal is used in the largest sense and includes, states, counties, municipalities, schools, and other districts.

The three principal methods used for financing public improvements are from (1) funds derived from ordinary or special tax levies; (2) funds secured by some form of special assessment imposed on property of specified districts; (3) the proceeds from bonds which are either issued as a lien against specific classes of property, specific pieces of property, or the whole credit of a political unit. A fourth method of financing might be called from miscellaneous sources such as gifts, contributions, etc. This last method will not be discussed, as it cannot be considered a constant factor under political control.

The employment of tax funds for financing public improvement is in more general use than is commonly believed. Sometimes it takes the form of specific appropriation from the general fund. Other instances provide that certain special taxes shall be used for designated expenditure. An example of this form is the use of the gasoline tax for road construction. Many other examples might be quoted, but since this is so readily understood, no others seem necessary. Another plan of using tax money direct is to allot a certain proportion of the tax levy for public improvement.

These methods of using tax money direct for public improvements have decided advantages, in that the cost is reduced to a minimum in a pay-as-you-go method, overhead is reduced to a minimum, legal costs, collections, bond issue costs, assessment costs, and other miscellaneous costs are practically eliminated. There is, moreover, no possibility of a future liability of principal or interest or both falling due when there are slack times and the ordinary tax levy itself is difficult to meet. Interest, which is a considerable item, is entirely eliminated. There are examples where communities have been very successful with this method. It should be used only where the improvement is for the general benefit of all who pay the taxes.

If properly budgeted over a long period of time, this method of financing public improvements eliminates practically all of the objections to the other methods which will be discussed.

There are objections to this method, in that not sufficient funds can be secured to execute projects. This is particularly true in new and rapidly growing communities such as we have in the West. The West is beginning, however, to outgrow its youth and become more fixed. San Francisco is celebrating now (1926) the one hundred and fiftieth anniversary of its founding. Los Angeles is preparing now to celebrate in 1931 the one hundred and fiftieth anniversary of her founding. It is also argued that the voter will not sanction improvements if he knows he will have to pay for them. This is true in practical politics, but a poor argument in economy, for the taxpayer pays the bill under all but the gift plan. Educate the voter to the most economical method by presentation of the facts. Do not deceive him merely on grounds of expediency.

There is a legitimate objection to paying for public improvements of long life out of current taxes, on the ground that present taxpayers pay all the bill and only get a fraction of use, and, therefore, the payment, in part at least, should be passed on to future enjoyers. This is a fair argument, but could likewise be applied to all of the present generation's contribution to the succeeding, and logical reason for the condition of dependency on the following generation of such a large proportion of persons over 60 years of age. This argument is used to extend payment for public improvements so far into the future as to make certain the extinction of the improvement before the payment is completed.

Each year sees additional public improvements of many kinds requested, and, if more of the present needs were paid for as we go, on a plan which would indicate the future needs, and all luxuries were eliminated, very soon an annual appropriation as large as would be required for interest and redemption would take care of the total necessary annual expenditures of this sort. An example may be cited in the case of the State of California, which in 1925 expended $4,150,480 in interest on bonds, and only $835,000 in redemption. It is evident that in the end more could be secured for the people if the payments had been reversed. In this event there would be available over the borrowing plan all the costs of borrowing including overhead, discounts, and interest. The interest alone on most public improvement bonds is larger than the principal.

Public improvements paid for from current taxes have been increasing in volume, but the amounts have not been segregated. An idea of the percentage expended for some of these general purposes may be ascertained from figures published by the Industrial Conference Board. These figures, however, include funds derived from bond issues.

In state expenditures, highway outlay is the largest, followed by that for education and eleemosynary establishments, with penal institutions third. For local governments education is first, debt charges of interest and retirement second, and highway a close third. Out of a total of $6,497,000,000 expended by state and local governments in 1913, some $1,848,000,000 or 28.4 per cent for education (including libraries); $1,330,000,000 or 20.5 per cent for highways; $1,072,000,000 or 16.5 per cent was expended for interest and retirement of public debt; while only 5.5 per cent was used to meet general overhead cost of government.

The use of special assessments levied on property of designated districts to finance public improvements such as streets, roads, paving, drainage, flood control, irrigation, water, light, schools, mosquito abatement and what not is general. The methods and specific acts may vary, but the principles are the same; therefore, I will draw my examples from conditions in California with which I am more familiar.

The procedure in these cases of special assessment districts is carried out by forming an improvement district for the purpose intended under an appropriate act, either general or in some cases a specific act. California has had several acts for organizing improvement districts usually known by the year they were enacted, as 1911 Act, 1915 Act and recently the Mattoon Act has been brought into use. This new act, drawn entirely with the psychology of the public official trying to get an improvement through for those demanding it, has so few safeguards and limitations and gives so much power as to be a possible instrument of confiscation. Almost anything may be done under this act. It has some meritorious features, but like other improvement district acts, its lack of limitations casts grave doubts as to its constitutionality.

Petition by voters in the affected district, by declarative ordinance by municipal officials or by vote where necessary are the methods used in forming a district. The details will not be presented because of the time limit.

The boundaries of the district are drawn and the costs of the improvement are estimated and then the costs are assessed against the property of the district. Under some acts only real estate bears the assessment, in other instances only land, and in other cases personal property is included. Objections may be raised to all these assessment cases, but the greatest objections may be given for including personal property where the improvement is of a permanent nature. If the assessment is high, this type of property moves out and leaves a larger tax burden on the remaining property.

A great danger in making assessments in these districts revolves around the attempt to have property "assessed according to benefit" derived from the improvement. This is a work which requires the most expert skill and then is never entirely satisfactory. Another problem is that of the area to be included in a district. That all the benefited area should help pay for the improvement, seems to be a general rule; but then, what of overlapping districts both as to benefit and assessments? A whole city may benefit from the opening of a street, but clearly adjoining property would generally benefit most. With this in mind some cities, Los Angeles, for one, contributes from a general fund and assists with such improvements as are for the benefit of all the people. The problem of overlapping of assessments and benefits has not been satisfactorily solved.

Another great danger in this problem is that of having too great a burden either through too costly an improvement or one too expensive for the property in the district to bear. Sometimes this may be solved by enlarging the district, other times the only solution is to abandon the project as too expensive in the same way a private concern would do. Unfortunately, governments seldom do this.

After the assessments have been determined, bills are sent or notice given that assessments are due, and they must be paid within thirty days or they are declared delinquent and property may be sold for taxes. In such case penalty and legal fees fall on the property and must be paid by the taxpayer to clear up his property. The taxpayer can, if assessment is over a specified amount ($25.00) in one act, elect to pay by installments and bonds are issued accordingly, usually bearing 7 per cent interest. These bonds will be discussed under the following section on bonds.

Three objections to this method of financing public improvements appear at this point. One is the high interest rate on the installments to be considered under bonds.

The second arises from the fact that notices of special assessments frequently fail to reach the property owner, either by accident or design of those who may profit by tax sales, penalties, or legal fees connected therewith, and consequently the property owner has an annoyance and added burden. This could be remedied by making certain that notices reach the property owner or by placing all special assessments on the regular semi-annual tax bills.

The third objection which is the most serious arises from the fact that work done under public contract assessment is as much as 25 per cent greater than those financed by municipalities. This additional 25 per cent must come out of the pockets of the taxpayer. The system then is extravagant.

The San Francisco Bureau of Governmental Research in 1923 made a study of costs of the methods of financing and performing new street construction by the city pay plan and public contract by assessment. The result of this study covering a period of eight years proved conclusively that public contract prices, on the average, were nearly 25 per cent greater than those charged for city pay work. This analysis showed that contractors increase their bid price under public contract assessment projects by an allowance in their bids for the anticipated percentage of property owners who will elect to pay by installments. These bonds must be sold by the contractor at a discount if he wishes money to operate with and it is found that most of them need the ready money.

This discount does not make up all the 25 per cent, for under the assessment public contract method, the owner has thirty days after the work is completed to decide upon cash or installment payments. The contractor must then have enough capital to carry the whole job and he must capital by selling the special assessment roll at a discount to some investment house. This discount or the interest for the carrying capital must, of course, be added to the bid.

There is yet another reason for a part of the 25 per cent addition by the contractor and also the high interest rate of 7 per cent on the bonds issued. This comes from the inherent weaknesses in the Improvement District Acts in other states as well as in California under which special assessment districts are organized. These acts are such that the contractor, and especially the honest one, may possibly have all sorts of annoyance and grief with his contract—delays in payment, in acceptance, delays in proceedings, legal entaglements, delays in collections, injunctions, etc. And the laws are such that the municipal officials are not liable—they individually escape once the contract is let. The contractor and the investment house financing him must have, as it were, a margin for insurance against the contingencies listed above. Here again the taxpayer may reduce costs by remedying the apparent effects.

San Francisco, largely through the instrumentality of the Bureau of Governmental Research, adopted an amendment to her charter approved by the State Legislature, January 21, 1925, authorizing the establishment of a "Public Improvement Revolving Fund," so as to have cash to pay for improvements and save this 25 per cent excess of contracts for assessment districts over city pay contracts. This plan deserves the closest study by every member of this conference.

Mr. Joy Winans, Chairman of the Los Angeles City Committee of California Taxpayers' Association, has worked out a similar plan for Los Angeles, but with extensions which propose, in addition to doing all that the San Francisco plan does, also to reduce interest rates from 7 per cent to at least as low as 6 per cent on all special assessment street improvement bonds. Here is a method worthy of close observation by all taxpayers.

The third and last method of financing public improvements to be discussed is that of using the proceeds from bonds. These bonds may be issued as liens against specific pieces of property as in the case of special assessment district bonds referred to above, specific classes of property, or the whole credit of a political unit. This method of financing public improvement is the one most generally used and one which has been increasing at a tremendous rate in recent years. The growth may be realized from recent statistics on municipal bond sales in 1925 compiled and published by the COMMERCIAL AND FINANCIAL CHRONICLE in their STATE AND MUNICIPAL COMPENDIUM for June, 1926. These figures include all bonds of states, counties, municipalities, school and other districts and naturally include bonds which are not for improvements. By far the largest bulk of them, however, are for improvements. Only large issues which are of a permanent nature are included, so that the total figure would be greater if issues of $25,000 and less were included.

The grand aggregate value of all municipal (municipal used in largest sense as indicated before) bonds marketed for 1924 was $1,398,953,158, increase of over 30 per cent over 1923 which totaled $1,063,119,823. The 1925 firmness in the money market interfered somewhat with ready sale of such securities, but even then the municipal bonds disposed of ran over 1924, reaching $1,399,637,992—a new high record by a substantial margin.

The 1925 figure was only slightly less than $1,400,000,000 and the fifth successive year the sales have been a billion dollars or over. Prior to 1919 there was not a year where it ran over $500,000,000 and 1914-1917 the yearly totals were close to $500,000,000. The publication referred to above as collecting these statistics publishes a table showing the issues for the last twenty-five years carefully analyzed. The war period kept such issues down to a minimum. Thus it is evident that since 1919 we have had a spree of municipal bonding—the issuing of so-called tax-free securities. In 1921 the billion dollar era began, 1922-23 the total dropped slightly, and in 1924-25 it was rapidly moving up. The future gives promise of a greatly accelerated increase—especially so if all the proposals in California carry at the coming election—and unless the taxpayers everywhere begin to realize where such procedure ends. There is no shrinkage likely to occur in the immediate future.

It is true that the removal of the surtaxes, especially in the Revenue Act of 1926, reduced the value of the non-taxable feature of these securities, but apparently did not reduce the demand enough so that a slight increase of interest rates on them will make them favored securities in competition with private enterprise.

The total of issues sold does not entirely represent the increase of indebtedness in bonds, for there has been an increasing retirement of older issues. The following table shows the net additions for the past three years:

GROSS AND NET INCREASE IN MUNICIPAL INDEBTEDNESS

	1925	1924	1923
New issues	$1,399,637,992	$1,398,953,158	$1,063,119,823
Retirements	284,278,408	261,520,657	234,480,299
Net additions	$1,115,359,584	$1,137,432,501	$828,639,524

The net additions for 1925 were smaller than those for 1924, but still well over a billion dollars. The level of debt is much larger than previously.

The largest reductions have been in lessening of soldier bonus issues which are not improvement securities.

The increase of political subdivisions in the sale of bonds is seen in the following table:

BOND SALES BY POLITICAL SUBDIVISIONS 1923-1925

	States	Counties	School Districts	Municipalities and Towns
1925	$161,919,410	$229,414,382	$198,054,464	$810,249,736
1924	249,516,730	206,823,108	174,407,180	768,206,140
1923	232,725,090	170,486,574	152,048,127	507,860,032

The time limit prevents a reading of the interesting tables published by the *Commercial and Financial Chronicle* on the Geographical distribution of these bond issues with interest rates, and the purposes of their issue.

only the North Central Division of the United States showed a contraction in 1925. Another is that 1925 bond prices were the highest since the war in that at the peak in 1925 the very highest grades sold at 3.75 per cent, others at 4 per cent, very few at better than 4 per cent and most of the issues of the cities at 4.15 per cent to 4.25 per cent, with some as high as 5 per cent and others at 6 per cent and over.

Short time bonds of assessment districts are not listed and, as noted before, run to 7 per cent. If these and other short term issues were included the total would run well over $2,600,000,000 total sales for 1925.

Los Angeles was among the cities both in 1924 and 1925 conspicuous for the extent of their appeals to the bond market. In both years selling was over 30 million dollars.

It should be noted that interest rates seem to be increasing on all municipal issues. In 1901 the 3 per cent issues formed 8.42 per cent of the total, 3½ per cent bonds 52.41 per cent, and 4 per cent issues 20.96 per cent. In 1925 there were no 3 per cent issues, and 3½ per cent bonds only .06 per cent of the total, with 4 per cent bonds 19.27 per cent of the total and the balance at higher rates.

The purposes of these municipal issues for 1925 are largely for public improvements. The highest percentages being as follows: Roads and Streets 28 per cent; Schools and School Buildings 23.14 per cent; Improvements 13.69 per cent; Sewer and Drainage 9.32 per cent; Water 83.8 per cent; General Buildings and Fire 4.16 per cent; Parks and Museums, Electric Light and Gas, Funding, Harbor and Water Front, Irrigation and Miscellaneous are each just over 1 per cent; Soldier Bonus, Flood Prevention, Transportation Ferries and Canals are between ½ per cent and 1 per cent. The total of the value of all public improvement issues shows an increase and with very few exceptions an increase for all the individual purposes.

One city (Cincinnati) alone has had more than 700 outstanding issues during the last three years with the total for eight cities being 2,437 issues.

It is self-evident that all these bond issues with interest must be paid by the taxpayers. The liabilities involved in the aggregate amount of nearly $1,400,000,000 of such new issues annually is so great as to be beyond the comprehension of the ordinary citizen. This liability has never been calculated and it is doubtful if it can be with reliable. Serial bonds for 40 years bearing 5 per cent interest require a repayment of $2.02½ in principal and interest for each dollar borrowed, and if they bear 6 per cent and are for 50 years $2.53 must be paid in interest and principal. These types of issues are common in the West and the taxpayer may assume that ordinarily when he votes for a bond issue bearing 5 per cent interest or over he will repay more than two dollars for every dollar voted.

Local governments cannot go on issuing bonds at the rate they have been. The end of prosperity with bankruptcy either of our governments or of our standard of living will result. What is the remedy?

First, the establishment of economy-mindedness on the part of the taxpayers and officials, so that extravagant and unwarranted improvements are not required. And to the end that greater use shall be made of the pay-as-you-go method on a plan of budgeting public improvements on a cash basis so far as practicable.

Second, the reduction of interest rates on all public bonds, such as assessment district bonds, by correcting defects in the laws and establishing responsibility, and the judicious use of the credit of county, municipal and town governments for financing such projects, thereby reducing costs of improvements as much as 25 per cent and interest rates from 7 per cent to as low as 4 per cent or 5 per cent.

Third, the reduction of interest rates on ordinary municipal bonds where the credit of a political unit is pledged, by budgeting all public improvements over a period of years. The budget should be for not less than five years and preferably for ten or more years. This method will have the additional effect of stabilizing municipal bonds and keeping interest rates down, if not reducing them, of providing for those improvements FIRST WHICH ARE OF PRIMARY IMPORTANCE and will not permit tying up the bonding power by issuing bonds up to the legal limit in issues for projects of secondary importance.

Most political units other than states have legal limits for bonding as well as the limit set by the New York law for securities legal for investment of savings banks. Likewise, most bond issuing political units due to the orgy of voting bonds in the past few years, are dangerously near the legal limit and many are over the New York limit. There are, however, many public improvements which should be carried out. One pressing need for all the West is more and better water. In Los Angeles, and in California at large, we have many projects of primary importance which have to wait for a completion until secondary items are out of the way. A condition of embarrassment results and the logical thing to do is to take a balance sheet of resources and budget all public improvements for a period of years, so that adequate financing of primary projects may be planned and the municipal credit not be endangered. Once a budget is drawn with provision for emergencies, then it should be strictly adhered to and only such improvements made as are properly budgeted.

For more than twenty years in the United States

logical way to conduct government. Today it is generally accepted as an annual necessity for cities and counties and yearly or biennially for states. Great savings have resulted from this plan.

This short time budgeting is not enough for public improvements. Already a growing number of cities have prepared long time budgets for improvements and are adjusting finances to carry them into effect. Detroit has one of the most comprehensive plans based on a ten-year budget. Kansas City, Toledo, St. Louis and many other cities have also prepared ten-year budgets for public improvements. Western communities have more public improvements to make than any other part of the United States. Los Angeles city alone has more projects planned than any other city in the world. If any part of the United States needs a long term budget for public improvements the West certainly does. If at any time in the history of the United States an orderly and businesslike method of financing public improvements is needed it is now when new municipal bond issues have reached $1,400,000,000 annually and the taxpayers' liability is such that a sane plan must be evolved before progress is halted and reaction causes the pendulum to swing to the other extreme. Taxpayers, promoters and officials should work together for the best interests of all in a situation which demands a solution other than the impending Socialism which approaches when you take more than one-sixth of the annual income of all the people for the expenses of government as is now being done.

The afternoon session closed with the address of C. C. Chapman of Portland on "How Excessive Taxation Deters Industrial and Agricultural Development," and state progress reports by Mr. Beatty for Wyoming, and George Spalding for Colorado.

Tuesday Dinner Session

Tuesday evening, a dinner was given to the Conference, sponsored by the Los Angeles Chamber of Commerce, at which Dr. Johnson presided. It was addressed by Frank F. Merriam and Hugh Pomeroy.

Mr. Merriam has for many years been speaker of the California House, and, after some minutes of humor, which was much enjoyed, described the practical details of getting bills through a legislative body.

Mr. Pomeroy, secretary and director of the Los Angeles County Regional Planning Commission, which has jurisdiction in the territory outside the large cities, was an entertaining speaker. His address will be published in a later issue of The Tax Digest.

Necessity of Budgeting and Colorado River Development

On Wednesday, Joy A. Winans, chairman of the Los Angeles City Committee, spoke on "The Necessity of Budgeting Governmental Expenditures"; and the Conference closed with a luncheon, at which the costs of the Colorado River development were discussed by Prof. Reuel Leslie Olson, Department of Law, University of Southern California, who suggested the appointment of a permanent Colorado River Commission, and at which Congressman Elmer O. Leatherwood of Utah expressed the belief that at least six states should ratify the Colorado River pact before Congress could be expected to enact legislation providing for the development of the Colorado River.

1927 Conference to Meet in Santa Fe

On Wednesday, it was decided that the fifth annual Western States Taxpayers' Conference will meet in 1927 in Santa Fe, N. M. The officers of the Conference for the following year will be:

President, H. J. Hagerman, President, Taxpayers' Association of New Mexico, Santa Fe.

Vice President, Henry H. Rolapp, President, Utah Taxpayers' Association, Salt Lake City, Utah.

Vice President, Scott Z. Henderson, Tacoma, Wash.

Secretary-Treasurer, A. C. Rees, Secretary, Utah Taxpayers' Association, Salt Lake City, Utah.

Chairman, Executive Board, Milbank Johnson, Chairman, Board of Directors, California Taxpayers' Association, Los Angeles.

Advisory Committee: Arizona, Rudolph Kuchler, President, State Taxpayers' Association, Phoenix; California, Vance H. Evans, Executive Secretary, California Taxpayers' Association, Los Angeles; Colorado, George Spalding, Tax Commissioner, Mountain States Tel. & Tel. Co., Denver; Idaho, (to be named); Montana, John Edgerton, Secretary, Montana Taxpayers' Association, Helena; Nevada, F. N. Fletcher, Director, Nevada Public Economy League, Reno; New Mexico, Hugo Seaberg, Attorney, Raton, N. M.; Oregon, C. C. Chapman, Editor, Oregon Voter, Portland; Texas, John T. Smith, Editor, Texas Tax Journal; Utah, C. M. Brown, Utah Taxpayers' Association; Washington, C. E. Arney, Jr., Executive Secretary, State Federation of Taxpayers' Association, Seattle; Wyoming, M. O. Danford, Midwest Refining Co., Casper.

The Resolutions

The resolutions reported by the chairman of the Resolutions Committee, C. C. Chapman of Portland, had passed through the hands of the committee in the usual order and were adopted unanimously. They are

FEDERAL LAND

RESOLVED, that a committee of three be appointed to investigate and report on the advisability of urging the Federal Government to pay annually to states in which public lands are located, sums equivalent to the prevailing rate of taxes upon an equal acreage of similar lands in such states.

PUBLICITY

RESOLVED, that we recommend to state and local Taxpayers' Associations the use of paid display advertising space in their state and local newspaper press as constituting a responsible, economical and effective method of getting tax facts before the public.

SPECIAL INVESTIGATION

RESOLVED, that the Western States Taxpayers' Conference authorize the appointment of a committee of three whose duty it shall be to investigate and report at the next meeting of the Conference on the comparative per inmate costs of each of the state's institutions. Investigation to include penal institutions, corrective institutions, and curative institutions.

COUNTY GOVERNMENT

RESOLVED, that this Association appoint a committee to report at the next annual Conference on the advisability of designating and recommending the adoption of more modern methods in county governments and on the desirability of consolidating small counties in the interest of efficiency and economy.

UNIFORM ACCOUNTING

WHEREAS, the varying systems of accounting in use in different states, counties, districts and cities, render the work of Taxpayers' Associations much more difficult,

NOW THEREFORE BE IT RESOLVED, that the Western Taxpayers' Conference favors the adoption of a uniform system of accounting for each state, and all its subdivisions and if possible for all of the states within the scope of the Conference.

BUDGETARY SYSTEMS

BE IT RESOLVED by the Western States Taxpayers' Conference that we urge upon all states to provide that the state government and all its political subdivisions, including schools, shall operate on a budgetary system; that provisions by law shall be made for the proper enforcement and adherence to such budgetary system on the part of all public officials concerned.

BOND ELECTIONS

BE IT RESOLVED by the Western States Taxpayers' Conference that states be called upon to pass such laws or to take such other measures so as to provide that no bond election by the state or in any of its taxing units shall be held valid, unless at least 50 per cent of the qualified electors of such state or unit, shall cast their votes at such election.

SERIAL BONDS

BE IT RESOLVED by the Western States Tax-the preferable form of bonds, in the interest of economy and sound business administration in public affairs.

SPECIAL IMPROVEMENTS

BE IT RESOLVED that the Western States Taxpayers' Conference urge all states, subdivisions and districts to adopt the policy of operating on the long term budgetary plan for the determination of their improvements.

NATIONAL TAX ASSOCIATION

WHEREAS, there is rapidly developing a tax consciousness on the part of taxpayers generally throughout the United States, which is leading to the formation of representative statewide and regional taxpayers' associations, interested in aiding to bring about greater efficiency and economy, and

WHEREAS, there has been held by the fourth annual Western States Taxpayers' Conference assembled in convention at Los Angeles, California, October 11, 12 and 13, a full discussion covering governmental expenditures.

NOW, THEREFORE, BE IT RESOLVED, that this Conference respectfully request the National Tax Association to devote, as is being done at the 1926 meeting, a portion of its program at each annual meeting to the consideration of problems having to do with control and methods of public expenditures, and

BE IT FURTHER RESOLVED, that the National Tax Association be requested to extend full membership and recognition to properly constituted taxpayers' associations organized on a statewide and regional basis and representative of the interests of the taxpayers proper.

APPRECIATION

BE IT RESOLVED by the visiting delegates of this Conference that a sincere vote of appreciation be extended to Dr. Milbank Johnson for the unbounded hospitality which he has shown the visiting conferees and for the masterful manner in which he has presided over this Conference.

BE IT FURTHER RESOLVED, that a vote of thanks be extended also to the California Taxpayers' Association for the thoroughness and liberality with which it has prepared for this meeting; that the able services of Mr. Vance H. Evans, as assistant secretary of the Conference, be especially recognized.

BE IT FURTHER RESOLVED, that the Conference express its appreciation for the many courtesies extended to the conferees by the Los Angeles Chamber of Commerce.

A Press Advisory Committee

The editor of The Tax Digest, however, offered an additional resolution from the floor, frankly admitting that he did so for dramatic effect. He cited what he believed to be an habitual error of quasi-public bodies, in that they did not include the great body of journalists as an integral

fairs. The custom, he said, was for gentlemen to assemble and decide on what measures were necessary to save the country, and then to go to the press and say: "This is what you will print." He suggested that in every city there are working journalists who are constantly in touch with all phases of public affairs, and here was a vast storehouse of information which might be utilized to immense advantage by the Western States Taxpayers' Conference, and that the press should be taken into consultation as a primary and not a secondary influence. Therefore, the following resolution was offered:

RESOLVED, that the vast fund of information and judgment on public afiairs regarding taxation and the interests of the several communities which journalists of the different states have necessarily accumulated be utilized in the further study of taxation, by the appointment of a Press Advisory Committee, one member from each state, to report a plan to the 1927 Conference whereby this fund of information may be available.

Judge Rolapp of Utah offered an amendment which, with the resolution, was unanimously adopted, providing that there be appointed a thirteenth member of the General Advisory Board of the Conference, the thirteenth member to represent the press.

The Conference Committees

The committees for the Conference were:

Resolution: C. C. Chapman, Oregon. chairman; George Spalding, Colorado; F. M. Fletcher, Nevada; Adolph Kuchler, Arizona; A. G. MacKenzie, Utah; M. D. Lack. California; E. M. Sawyer, Idaho; Rupert F. Asplund, New Mexico.

Nominations: F. N. Fletcher, Nevada, chairman; E. M. Brown, Utah; R. A Vandegrift, California.

Permanent Organization: Henry R. Rolapp, Utah, chairman; C. C. Chapman, Oregon; Rudolph Kuchler, Arizona.

Place for 1927 Conference: Rupert F. Asplund, New Mexico, chairman; E. M. Sawyer, Idaho; V. H. Evans, California.

Send for the Fire Department

The probation nurse telephoned frantically to the physician:

"O, Doctor, your patient has 120 degrees of temperature. Come at once!"

"You don't need me," the doctor re-

THE TAX DIGEST
JOHN LATHROP, Editor
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Opinions expressed by writers herein are not necessarily the opinions of the Editor of this magazine, but are printed in the interests of free discussion.

ART COLLECTIONS AND FLOOD CONTROL DAMS

The great Stilwell art collection was under consideration to be brought to Los Angeles from New York City to cost $800,000. It was one of the choicest collections in the world. For fifty years Dr. John Stilwell had gathered these art treasures from the ends of the earth. He asked only a return of the expense he had incurred in making this collection. He generously sought no profit.

The money was to be contributed voluntarily by individuals to make up the sum of $800,000. There was to be no compulsion. Who contributed would do so of his own accord, to enrich the culture of the community.

The question arose as to whether or not public men and public bodies, among them the Los Angeles Chamber of Commerce, should endorse the appeal which was to be made to the people of Los Angeles to contribute the $800,000. The Chamber stipulated that, prior to such endorsement, prior to any purchase, there must be an independent appraisal of the art objects included in the collection. It had already been appraised by a competent Los Angeles art critic.

However, the question also arose as to endorsement by the Chamber of Commerce of a bond issue of $35,300,000 for flood control, the money to be contributed perforce by the taxpayers, and the sum forty times as great as that involved in the art collection. Endorsement was given without independent checking.

Why this difference? It was proper to reappraise the art collection, because then those involved in the art proposal could say to the people of their city, we have assured ourselves that this much money is needed and that more than actual value will be returned when the collection, if at all, is obtained.

Should there not be equal vigilance with the taxpayers' money, when it is not a case of voluntary contribution?

The Chamber of Commerce was rational, normal, fair, consistent as to the art collection. Was it equally so as to the flood control·bonds?

Must there not be a fundamental reform of procedure? Are not taxpayers entitled at least to the same degree of solicitude as voluntary contributors are?

Both are entitled to such solicitude. Independent re-appraisal of the art collection was right. Independent checking of the flood control plans would have been right, too. Wherein may anyone point a difference in the two cases?

HONESTY AND ACCURACY OF WOMEN

One of the large department stores of a California city accommodates the public by the cashing of personal checks, regardless of whether purchases are made in that store or not. On a recent day this store cashed such personal checks aggregating $15,000. They all passed through the hands of one man who "O.K.'d" them for payment by the cashier. Of that $15,000, only one check, one for $15, proved to be not good. This was one-tenth of one per cent of the total. Two small checks in this large aggregate were temporarily held up, marked "Insufficient funds," but, upon being sent back, were promptly cashed by the banks upon which they were drawn. These checks were for small amounts, nearly all of them drawn by women, probably ninety per cent of them.

In these days of pessimistic comment on the alleged unreliability of people in this post-war period, such a record is both interesting and instructive. It

points this moral—that the great majority of persons are honest, and that mistakes when made are usually, almost always, honest mistakes.

But the further lesson to be learned from this is that there were so few even of honest mistakes made. Men who joke about women keeping their bank accounts would better read this statement with some care and revise their habitual comments, even if made in a joking manner. From a business standpoint, the loss of one-tenth of one per cent of this accommodation of small personal checks doubtless was compensated by purchases, the profit on which many times over wiped out the small deficit.

However, this record is a tribute to the judgment of the store's representative who "O.K.'d" these many checks. His position should be quite secure with his organization.

Under the Editor's Study Lamp

The official monthly publication, "New Reclamation Era," of the Bureau of Reclamation, Department of the Interior, Washington, announces the appointment of Louis C. Hill to membership on an important board of engineers to study the proposed new damsite between Avalon and McMillan reservoirs on the Carlsbad project.

Mr. Hill, who was formerly supervising engineer of the Bureau of Reclamation, and who is now a consulting engineer with the Department of the Interior, will represent the interests of the water users. S. O. Harper, assistant chief engineer of the Bureau, will represent the Bureau, and Oro McDermith, a former engineer of the Bureau, will represent the Secretary of the Interior.

It will be noticed that here is another instance of preliminary studies before the endorsement of a proposed damsite.

California Taxpayers' Association is confident these studies will be prosecuted with thoroughness and high skill. Mr. Hill is the engineer employed by this Association to report on the San Gabriel damsites, which therefore knows the conscientious character of his technical work.

It is also learned that Mr. Hill has been retained by the Mexico City Light & Power Company in connection with the construction of a very large dam in Mexico. This company carries a capitalization of many millions and is in a position to procure the best of engineering skill. Mr. Hill has been in Mexico in connection with this enterprise during the past month.

For the first time in history, so we be-

objected to the publication of population figures for his home city on the ground that they were too high. Ray L. Riley, State Controller, recently assigned Pasadena 80,643 population, and gave the figures to the Sacramento correspondents. When they appeared in the Pasadena newspapers, Secretary William Dunkerly, of the Pasadena Chamber of Commerce, said they were about 5000 too high, and that Pasadena really had only about 75,000 persons permanently living there. Controller Riley must have turned over in his official chair when Secretary Dunkerly's conservative stand became known to him. Furthermore, it would be not at all surprising if the Ancient and Accepted Order of Secretaries sit in judgement on the recalcitrant, and oust him. Here is sympathy for the possible severity of the judgment, and high admiration for his courage. However, may his tribe increase!

Lloyd McAulay of Stanislaus County thinks the August number, devoted almost wholly to the Sonoma County Report, was worth while. He writes: "Herewith subscription for one year. I was very glad to get a recent number devoted especially to a single county, and would gladly pay a year's subscription for a similar number devoted to Stanislaus County. That's what I call constructive criticism."

Writes William P. Lathrop, a financial man of Walla Walla, Wash.:

"I have watched with interest the growth of your Tax Digest. It appears to have grown in a year from a pamphlet to a respectable and well gotten up publication. The work that you are doing is construcplexed the world ever since governments were known, there is no need to fear that it will not continue to need attention."

The great Stillwell art collection to purchase which, for $800,000, efforts are being expended in Los Angeles, has been reappraised by Dr. Frank Muller of New York, who values it at $1,046,855. The original appraisal of the collection was $1,250,000.

Dr. Muller declared: "This collection in my opinion is admirably suited for the purposes in view, and contains a vast amount of high class art material, not only of great rarity, but for educational requirements of a great metropolis a distinct and unique acquisition. I know of no other aggregation outside of the principal museum of European capitals and three or four cities in the United States that is so representative in most of the phases of pictorial, sculptural and applied arts of the past centuries."

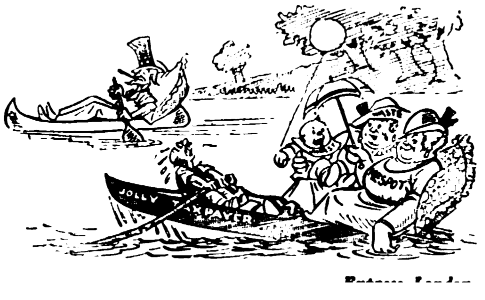
The principle of independent appraisal was applied very happily.

"I enclose my dollar for California Taxpayers' Association with my sincere admiration for the splendidly sustained character of The Tax Digest. It is always conspicuous for ability and accuracy," comes from A. Moresby White.

College Students Sign Own Death Warrant

As a stunt at Oklahoma University recently, a petition was circulated ostensibly asking for a holiday when it really requested the faculty to remove all credits, suspend them without a hearing and to shoot them at sunrise. More than three hundred students were taken in by the hoax.—*Southern California Trojan.*

LONELY UNCLE SAM!



The Dignity of Just Taxes

Judge McCabe of the Indiana Supreme Court as shown in the case of State v. Express Co., 144 Ind. 560, said:

"It is but natural that the tax gatherer should be made an unwelcome visitor by many good people. But the good citizen should take comfort in the payment of his taxes when reminded that it is such payment that enables the majesty of the law to walk by his side and shield and protect him against the lawless and violent both day and night in the enjoyment of life, liberty and property."

What Are Taxes?

Judge Cooley has said: "Taxes are the enforced proportional contribution from persons and property, levied by the state, by virtue of its sovereignty, for the support of government and for all public needs."

When Caesar Taxed All

The fact that all should be taxed is not even new. In Holy Writ we find this statement:

"And it came to pass in those days that there went out a decree from Caesar Augustus that all the world should be taxed."—Luke II:1.

LITTLE BOY BLUE

Annual Camouflage of the Tax Burden

By DEPARTMENT OF RESEARCH, California Taxpayers' Association

ARTICLE NUMBER ONE

This is the time of the year when we have the annual camouflage of the tax burdens in the several counties of California. The supervisors of the counties met during the first week in September, as required, and set the tax rates for the coming fiscal year, 1926-27. They either raised or lowered last year's rate, and now the rates have generally been announced, and the customary annual comparing of the several county rates with last year's rate and with rates in other counties, is going on.

In these comparisons and discussions, the tax burden which the taxpayer must bear is camouflaged in a discussion of rates which is only a part of the story. In the first place, usually only the general county rate is considered, and the fact stressed that it is lower than last year or lower than some nearby county.

Any propaganda which takes into account only the general fund rate, neglects to account for the grand total the taxpayer must pay. The taxpayer has not been generally interested in the different items which go to make up his total tax bill, but he is becoming inquisitive, and this previous camouflage does not deceive him as it did. The amount of money which he is asked for by the tax collector, and the advertised tax rates, are so far apart that the taxpayer is becoming impressed with the fact.

The rate for the general fund may be as low as a fractional part of a dollar per hundred dollars of assessed values. This may represent economy and efficiency on the part of those administering the general county government. It is commendable when this rate is kept down. But it is camouflaging the issue, if nothing is said about the many special levies and taxes to retire and pay interest on bonds. all of which contribute to make up the staggering total tax burden in some localities.

It may be true that the general rate is low and less than in the majority of the counties of the State, but that is small comfort when special taxes for the multitude of special improvements, school districts, road districts, sewage and sanitation districts, fire protection districts, drainage districts, boulevard districts, flood control districts, irrigation districts, and the many other THIS AND WHAT NOT DISTRICTS, enlarge the total to figures which produced an intolerable burden on the taxpayer.

ASSESSMENT

This is not the full extent of the camouflage in this annual discussion, for the rates are by no means the only thing to consider in determining the comparative tax burden in the several counties. Assessed valuations are as important as tax rates. Counties with identical tax rates may not have the same tax burden, because of the different ratios of assessed values to actual values. We find that the assessed values in the several counties range from 30 per cent to approximately 80 per cent of the true values. Thus, if one county assess at 30 per cent and the adjoining county at 60 per cent and they have the same rates, the tax burden is only one-half as heavy in the first county as in the second. The only way to strip off the camouflage is to adjust all rates before comparison to the basis of 100 per cent actual value.

Sometimes a boasted cut in tax rates does not mean in any degree a lessening of the taxpayer's bill, for this lowering of rates, and much ado about it, may be only a smoke screen to cover up a general and blanket increase in assessed valuations. The increase in assessed valuations also carries with it a greater total tax bill, for, although the general rate may be lowered, many special taxes are fixed or tend to remain at the maximum allowed by law. Likewise, any considerable decrease in assessed values in a county automatically places a greater tax burden on the remaining property, unless expenditures are proportionately cut.

In the case of bond issues for improvements, the obligations contracted must be met and no reduction of expenditures is possible in this respect. So the question which should be asked, when assuming the burden of a bond issue, should be not only, can we afford this improvement? but also, can we afford this improvement, and safely assume to carry this obligation, even if times are not so prosperous as at present? Thus every proposal for increased public expenditures should be carefully analyzed.

Everywhere the cloak of mystery surrounding the levying of taxes should be torn off. The taxpayer should force the abandonment of the theory we inherited from the time when kings were in vogue, that the best policy for tax-levying bodies, congress, state legislatures, county boards of supervisors, and city fathers, is to cover up and hide from the taxpayer the amount he is called upon to give for the support of government and public improvements. The theory has been and still is held by tax gatherers, and, I regret to state, is still taught in our courses in economics and political science in the high schools, colleges, and universities of this republic and the State of California, that the average citizen will quietly submit to a large indirect tax, when he would rebel if required to pay even a fraction of this amount directly to the tax collector. What is more, it has worked in the past and is working today and most likely will continue to work in the future, and to the detriment of the taxpayer, unless he becomes informed concerning the real burden of taxation.

Compulsory publicity covering every phase of taxation with the resultant education of the taxpayer, and a stripping off of the camouflage cast over tax matters. will have a salutary effect. Merely letting every taxpayer know that when he votes for any public expenditure he can be assured that the money will come out of the pockets of the taxpayer, will help. Also. if he knows that, when he votes to borrow money on bond issues, it means he must pay out in interest charges at least one dollar and frequently more for every dollar borrowed, he will act more wisely and not be so apt, in prosperous times, to assume obligations which in the future may be burdensome to meet.

"An Orgy of Spending"

William Mulholland Warns Against Careless Issuance of Bonds

The world has become immersed in an orgy of "reckless expenditure" such as has never before been experienced, F. S. A. Scott, actuary of the Savings Bank of Glasgow, Scotland, told the world meeting of savings bankers. The bankers are attending the annual conference of the National Association of Mutual Savings Banks, which is meeting jointly with the International Thrift Institute of Italy.—Recent Associated Press dispatch from Philadelphia.

A significant statement was issued by William Mulholland, chief engineer of the Los Angeles Municipal Water Bureau. printed in the Los Angeles Times, and warning against indiscriminate issuing of bonds. Mr. Mulholland referred to the aqueduct which will be constructed to convey water from the Colorado River as likely to cost from $150,000,000 to $200,000,000. He said:

To the Honorable Board of Water and Power Commissioners:

As you are aware, the engineering department of the Bureau of Water Works and Supply for the past year has been actively engaged in the making of comprehensive surveys with the view of obtaining a water supply from the Colorado River for the City of Los Angeles and neighboring communities. The distance being so great and the topography intervening between Los Angeles and the Colorado River being so extremely complex, it naturally requires a great deal of time to analyze thoroughly all of the data and properly to estimate the ultimate cost of such a vast project.

In the meantime, the people of Los Angeles city and county have had no preparation in anticipation of the probable tremendous cost of this vitally important work. Because of this condition and because of an alarming tendency toward a perfect orgy of projects involving huge expenditures of bond moneys, I deem it highly important at this time that the people be apprised of the rapidly approaching necessity of undertaking construction of the Colorado River aqueduct and other allied projects. It is of the highest importance that the people have in mind the necessity and the great cost of this Colorado River project before they decide to give unlimited and unrestrained approval to all the costly projects now being laid before them.

Otherwise there is grave danger that the city's and county's bonding power will be completely exhausted in advance and to the exclusion of the most vital project of all—the project to provide them with the absolute necessity of domestic water.

Peril to the Southwest

Up to the present time we have deemed it imprudent to issue anything that might be considered as an alarmist preview of the bonding situation confronting this city and county. But the board will remember that this county has been experiencing such continued and persistent droughts that our failure to fully appreciate every phase of this situation might prove fatal to the prosperity and welfare of the entire Southwest.

It was originally thought that we should wait until our engineering department has completed its surveys and cost estimates on the Colorado River aqueduct project before issuing such a document as this. We now find that it will require at least two more months to complete this work. In the meantime, within a few weeks, there will be presented to the people the question of voting bonds to very large amounts for other purposes. With this situation confronting the people, it is imperative that they be put in possession of all the facts before they decide to approve the very great expenditures provided for in these bond issues.

It is certain that the Colorado River will require an expenditure of at least $150,000,000. It may require the investment of $200,000,000. This work must be pushed forward within the next few years, even though we are favored by periods of normal rainfall.

It is my conviction that the situation just set forth is of the gravest import to our city and county, and should be brought to the people's attention without further delay.

L. A. CITY COMMITTEE OPPOSES $26,000,000 FLOOD CONTROL BONDS

The proposed $26,000,000 bond issue for Los Angeles County Flood Control is opposed by the Los Angeles City Committee of California Taxpayers' Association. Voters are recommended to vote "NO" in a statement issued by the City Committee, countersigned by Joy A. Winans, chairman.

Two years ago $35,300,000 of bonds were voted for flood control. Some of the work provided for by these bonds has already been done, and the actual cost is over-running the estimates given to the public when the bonds were voted, as illustrated by the following:

	Original Estimate	Actual Cost	Revised Estimate	Per Cent or Original Estimate
San Dimas Dam	$278,000	$600,762	....	216%
Devil's Gate Dam	290,000	452,745	....	156%
	$568,000	$1,053,477	....	187%
Sawpit Canyon Dam	$241,000	....	$600,000	249%
Big Santa Anita Dam	586,000	....	1,000,000	171%
	$827,000	....	$1,600,000	193%

No revised estimates have yet been made on the great San Gabriel Dam, the original estimates for which were $25,000,000. If the above trend be maintained, voters may expect it to cost $40,000,000 or more.

Were the flood control projects covered by the $65,000,000 of bonds already voted and asked for—$35,300,000 two years ago and $26,000,000 proposed on the Nov. 2 ballot—to overrun as indicated above, *the total amount would be close to $120,000,000* — and it is officially announced that still more bonds are to be asked for.

It is known that the Los Angeles City Committee was moved to its action of opposing the $26,000,000 bond issue because of indubitable evidence that there had been a lack of preliminary engineering, hydrographic and economic studies.

ENGINEERS AND ARCHITECTS OPPOSE PROPOSED $26,000,000 FLOOD CONTROL BOND ISSUE

The Los Angeles Chapter, American Association of Engineers, and the Los Angeles Chapter, Engineers and Architects Association, have issued this report opposing the $26,000,000 flood control bond issue proposed on the Nov. 2 ballot:

The Board of Directors of the Engineers and Architects Association, Los Angeles Chapter, American Association of Engineers, fully appreciates the importance of further flood control work in the County of Los Angeles, but we wish to express our disapproval of the present proposed bond issue in the amount of approximately $26,000,000.00, for the following reasons:

(1) We are convinced, from a perusal of the report of the Flood Control Department on this bond issue, that there has been no careful analysis of the various projects proposed, and it appears that the amounts stated for expenditure are the result of political compromise to influence the election in favor of the total amount of the bond issue.

(2) We find that the proposed flood channel

in the west end of San Fernando Valley is designed with earth banks and with such gradients that the banks cannot be expected to resist flood erosion.

(3) We find that the May Canyon project in the east end of San Fernando Valley contemplates the transportation of flood waters across Pacoima Creek into the Tejunga Wash, and that this plan ignores the Los Angeles City Engineer's plan and present measures for the storm drain relief in this area. We believe this diversion of storm water to be illegal, illogical, unnecessary and not economical.

(4) We find the plans proposed for the Ballona Creek Channel and outlet to be entirely inadequate for the combined requirements of the upper area and the run off from Venice and Centinella Creek.

(5) It appears that the plans under this bond issue have not been coordinated with the carefully prepared plans of the Los Angeles City Engineering Department, and an attempt to carry out the work as planned will result in a positive waste of money.

(6) We believe that, before any further moneys are voted for flood control purposes, carefully prepared plans for these purposes should be prepared in correlation with the plans of the various municipal storm drain requirements, and with the proposed structures in connection with the Colorado River water supply.

(7) In view of the City of Los Angeles bearing approximately 70 per cent of the cost of the Flood Control, all further plans and estimates in connection with this work should either have the approval of the Los Angeles City Engineer and the chief engineer of the Public Service Commission, or at least an honest attempt should be made to prepare these plans and estimates in conformity with the work of these departments.

Engineers and Architects Association,
Los Angeles Chapter.
American Association of Engineers,
Frank H. Olmsted, President;
Lynn I. Hirsch, Secretary.
408 South Spring Street,
Los Angeles, California.

A Uniform Budget Law for California To Be Drafted for California Taxpayers' Association

By VANCE H. EVANS

Executive Secretary, California Taxpayers' Association

At a regular meeting of the Board of Directors, California Taxpayers' Association, held October 13, discussion was had relative to the state proposals that are being presented to the taxpayers and voters on the November 2 ballot, and also the desirability of having in California a uniform budgetory law applicable to counties, cities, school districts, and other political subdivisions.

Mr. M. D. Lack reported on the progress of the study that had been made relative to improved budget requirements for state units. He outlined to the Directors the limitations on the powers of the Legislature to make necessary and desirable changes in budget procedure. He reported that a complete draft of improvements in that procedure, which he felt sure would be entirely acceptable to all subdivisions, would be prepared, and, when completed, would be taken up with revenue officials for the purpose of securing their suggestions and approval in order that it might be in final form for presentation to the 1927 sessions of the Legislature, providing it meets with the approval of the Association.

The findings as to the effect of the ballot proposals were presented to the Directors by the Vice-Chairman and Tax Counsellor. M. D. Lack, and by Professor Rolland A Vandegrift, Director of Research, who had been making a study of the effect of the proposals during the past month.

It was the opinion of the Directors that certain of the measures pertaining to revenue should be given consideration and a recommendation based on findings made for the guidance of the voters.

Proposition No. 1, which is additional bonds for disabled veterans, was approved as self-supporting and not affecting taxation.

Proposition No. 5, having to do with an increase in salary for state officials, and to some extent increasing the fixed charges of the state, was approved on the ground that it would probably bring to these positions more outstanding individuals, and thus increase the efficiency of the several branches of government to such an extent that savings, far in excess of the increase, might be obtained.

Proposition No. 8, providing that $5,000,000 a year for a five-year period be taken from the general funds of the state for the purpose of constructing highways, was disapproved, in the belief that the funds of the state would be insufficient to meet the recommendation of the act, and that it would necessitate either increased tax rates, new sources of revenue, or an ad valorem tax on all the property within the state.

Proposition No. 10, providing $8,500,000 for state buildings, including administrative and educational, in San Francisco, Sacramento, Berkeley and Los Angeles, received the approval of the Board upon the basis that the improvements proposed were necessary, and, if provided at this time, would no doubt be the means of bringing about added efficiency in University work and save much in rentals now being paid for state offices.

Proposition No. 11, to exempt from taxation certain secondary schools, was opposed by the Directors, as an extension of an already objectionable practice of exempting property from taxation.

Proposition No. 18, proposing to issue bonds to the extent of $500,000,000 for the acquisition of water and power rights and the development thereof by the state, is opposed, upon the ground that this amount of money is not necessary, the policy as advanced is unsound, and that there are no plans or safeguards worked out to protect the taxpayers.

Proposition No. 19, which permits the pensioning of judges, met with the approval of the Directors, for the reason that it would have a tendency to call to the bench a higher type of official, and warrant continuance in such service.

Proposition No. 22, exempting forest trees from taxation until forty years of age, received the approval of the Directors, for the reason that it does not represent an exemption of property now in existence from taxation, but rather will encourage and bring about added property values and also be the means whereby California may protect her forests, and conserve, for the use of her people, the maximum of yearly rainfall.

Proposition No. 24, proposing to permit irrigation districts to use their funds for purchasing bonds of other subdivisions possessed of water rights, installations and further to transfer funds from one account to another, to be returned from taxes subsequently collected, was opposed by the Directors, on the ground that it would open the way to abuses, and while in part was rightly intended, the good it might accomplish is outweighed by danger of abuse.

Proposition No. 25, proposing to exempt property used for cemetery and burial purposes from taxation, was approved by the Directors, upon the ground that it merely legalized a practice that is now in effect.

With the exception of these proposals specifically mentioned, no action was taken by the Board on the other proposals on the ballot, it being the general opinion that these measures do not come within the purview of the purpose of this Association.

An Idaho Legislator Favors a Light Tax on Growing Timber

By LLOYD A. FENN, Kooskia, Idaho

Mr. Fenn, a native of Idaho, is an alumnus of the University of Idaho in Forestry, and of the University of Montana in Law, the publisher of the Kooskia Mountaineer, and writes from experience in the Idaho Legislature.—THE EDITOR.

Experience has shown the people of Idaho that its present method of taxing immature timber is wholly inconsistent with a perpetuation of the lumber industry and that it is not conducive to the planting of forests for commercial purposess by private industry.

Endless examples throughout the state prove the fact that unless a decided change looking to the proper method of conserving immature timber is made, the whole theory of maintaining a continuous crop of lumber will be defeated.

The reversion of deforested areas, which are in truth potential timberlands, to the several counties, under our present law regarding the passing of title for non-payment of taxes, is constantly growing and the condition is becoming an alarming one. Cut-over land is not alone involved in this reversion of potential timber areas. It includes as well the hundreds of acres of burned over timberlands which will not provide rentals, even for grazing, to meet the minimum tax.

Here we are confronted with the problem of placing in the hands of the state or its legal subdivisions a large acreage of purely timberland, agreed to be of value for nothing else, which did not yield the former owner a return equal to the minimum tax imposed upon the lowest class of taxable land, yet it is a land capable of producing a wealth subject to taxation, if properly fostered and reasonably taxed for the purpose for which it is to be used.

Some say that this method (imposing an unjust tax) is a good way to secure timberlands for the state. However, it is well known that such a subterfuge is unworthy of patriotic citizenship, contrary to good morals, and is an attempt to override our constitutional guaranty of property rights.

However, those who view the matter solely in the light of a taxation problem feel safe in assuming that the state cannot afford to undertake or rather assume an enterprise which is financially impossible under private management, much less acquire a property which will in time produce a revenue to the state when carefully fostered for that purpose.

There is no attempt here to inject a controversy relative to the theory of state-owned industries—that is beside the urgent question of equitable taxation of forest cover or immature timber as involved in the matter now under advisement by the people in California in the proposed constitutional amendment.

Idaho justly points with pride to its forest laws recently enacted; yet the laws are vitally defective in dealing with the question of taxation on immature timber. This state adequately cares for its present timber by fire protection statutes and laws designed to meet the needs of mature stands. However, the law will ultimately be fruitless unless some enactment be made which will effectuate the possible future supply of privately owned merchantable timber by insuring a protection to the investment which must care for and protect a business for at least sixty years before a financial return is possible, as in the case of timber. There is no other business which exists under like conditions—an initial investment, accruing taxes and protection costs, and a delay in returns for a generation—yet that is exactly what the lumberman is asked to do under present laws.

When considering the advisability of fostering an investment for the production of timber upon potential timberlands, it is necessary that we look to the future. By permitting or encouraging an owner to make an investment, subject to destruction by natural and human agencies, under an exemption from taxation for a period of years, it is not suggested that no tax be made when the crop is ready for harvest; but merely, that a delay in taxation be had until the harvest is ripe—deferring public exactions on account of the property while it is not only unremunerative, but in fact a constant cause of expenditure for protection against destructive agencies. No timberland owner will object to a just tax when a definite value is ascertainable, nor will he object to a tax on the land itself. if based upon a value comparative with the value for which the land is used.

The question is, will the state, in order to produce and foster a taxable wealth for future years, forego an unreasonable request at the present time?

This question prompts the study of the proposed constitutional amendment. There does not appear to be anything objectionable in the proposition. It has for its purpose the conservation of forests of immature age, as well as the inducement to private owners to put their timberlands to proper use. It does not prohibit the legislature from providing methods of assessment upon timber of more than forty years of age, in fact, the inference is that a tax shall be made. Further, the proposed amendment does not prohibit a tax upon the land itself for the purpose for which it is best adapted. In fact, the amendment appears to be a constructive measure designed to perpetuate an industry for California.

Survey Showed That Pasadena Might Save $600,000 in Improving Holly Street

The Research Department of California Taxpayers' Association at the request of the Pasadena City Committee, Charles L. Wright, chairman, has made a survey, economic and engineering, of the proposed improvement of Holly street in Pasadena. The report on the survey, which was based largely on engineering studies by Harry V. Wenger, opened the way to a saving of more than $600,000, the improvement of the street to be fully adequate and efficient from the standpoint of true city planning, traffic flow and esthetic considerations.

The matter came before the Pasadena Board of city directors Sept. 28, 1926, when representatives of the State Association appeared in company with a sub-committee of the Pasadena City Committee and made a statement. In substance it advanced the suggestion, which had been set forth in the official report of the Research Department. It was that, instead of widening Holly street to 105 feet, an alternative plan be adopted of widening it to 80 feet, that the procedure be under the Mattoon Act instead of under the 1915 Act, all of which provided an efficient improvement, adequate to all the needs, with a saving of approximately 40 per cent of the estimated cost by the original proposal. The statement in part was as follows:

Pasadena justly prides itself as an acknowledged queen among residential cities.

Pasadena may maintain such a reputation and continue to attract and hold desirable citizenship only by predicating its official action on the principle of equal justice to all, rich and poor.

An improvement of Holly Street has been proposed, and plans formulated for widening it to 105 feet. This improvement is proposed under the 1915 Act, which would assess the costs on all property in the improvement district—real estate, improvements and personal—regardless of the degree of benefit which would accrue to any particular piece of property. A lot which is situate so far away as to receive virtually no benefit from the improvement, would, under the original proposal, be charged pro rata to its assessed value as much as one of equal assessed value situate so as to receive a maximum of benefit.

Serious Phases of Taxation

These matters of taxation have assumed serious phases. It is time they received equally serious consideration, based on merciless fact-finding, through research and a review of the direction in which taxation is trending.

Here in Pasadena as elsewhere taxes in late years have steadily increased. It is an issue which is nationwide. While the Federal government has been reducing taxes about $2,000,000,000 a year, state and local governments, in the same period, have been increasing them $4,000,000,000 a year. This city in its fine residential character, in its determination to give to people the best of community advantages and necessities, faces many other expenditures to which it must commit itself in the near future.

All of them must be kept in mind if we are to treat the city as a thing organic and avoid the error of seeing one single proposal only as a thing apart from the organic whole.

We cite to the taxpayers of the district affected by this Holly Street proposal that this improvement is not the only new one to which they must contribute in the near future. These same taxpayers must share in the costs for the issuance of bonds for several millions of dollars for vitally needed, water supply extensions. This is the one great, insistent and absolutely essential commitment, which must be kept in mind ahead of all others. Then there will be additional proposals for schools which will cost millions of dollars; there will be other street improvements, totaling large sums; there will be parks and playgrounds.

There will be this city's share in the cost of county government and for flood control, which has already caused the authorization, and partial expenditure, of $39,800,000 of bonds, with a new proposal to issue more than $26,000,000 of additional flood control bonds, the total being more than $65,000,000, with other such bond proposals for flood control to come on in the near future. This city must bear its share of the proposed maintenance. These general prospective commitments must be kept in mind in connection with enterprises which will be on the program in the immediate future to keep Pasadena in the forefront of American residential communities.

The tax burden is already too heavy. The time is at hand for Pasadena, for all of Los Angeles County, for all of California for that matter, to search for ways and means to procure economy in government consistent with efficiency and progress.

Furthermore, let no one come here with a proposal for an improvement which contains the possibility of speculative profit to him based thereon.

A Summary

The whole issue boils down to this: Shall more than $600,000 be saved the taxpayers of the district involved without loss of efficiency in attaining the desired result?

Shall there be just and fair imposition of the costs in exact proportion to benefits to be derived?

Shall an 80-foot street be regarded as adequate for all traffic needs of Holly Street, as the evidence in this case proves; or,

Shall a few taxpayers in the district involved contribute more than $600,000, largely to enable them and others to stand on the steps of the City Hall and look down a vista 105 feet wide, instead of 80 feet wide?

Shall rational improvements be encouraged by economy and commonsense; or shall the taxpayers be discouraged to the point that they rebel and blindly vote "No" on all proposals, wise and unwise alike?

We are heartily in sympathy with city planning. True city planning at first suffered because the economic factor was not always brought into the equation. At first it was "the city beautiful," and economic considerations were largely ignored. Gradually, however, city planning has developed into a science and an art. The pressure of economic necessity compelled such a result. Pasadena is face to face with such a consideration in this instance, as it will be in many others yet to come. In a sense, we are at the parting of the ways. Intense feeling on the subject of taxation has been aroused everywhere. We can not ignore it. This does not mean that we stand in the pathway to stop the car of progress. Rather, true progress is to be had along the lines indicated, and this true progress will be attained only if we take into consideration the facts and principles which herein are laid before you.

The Facts Condensed

The original Holly street improvement proposal was the voting of bonds for $1,150,000 for a street 105 feet wide, paving costs thereon to be approximately $287,000, the total being $1,437,000.

The alternative proposal is for an 80-foot street, which adequately meets the needs, which would cost $600,000 for opening and widening, $212,000 for paving, a total of $812,000, the difference in saving to the taxpayers being $625,000.

These findings were arrived at by the Research Department of California Taxpayers' Association at the request of the Pasadena City Committee of is Prof. Rolland A Vandegrift, an experienced research man, and the engineering survey was made by Harry V. Wenger, an engineer who has lived nine years in California, who has had wide experience in this class of work and who of course is absolutely disinterested.

These findings may be trusted as adequate, sound and in line with the best practice in carrying on public improvements, and they realize, perhaps, the maximum of economy, at the same time safeguarding efficiency. In other words, the resultant indicated by these findings is completely adequate to the needs in hand and would reduce the tax burden materially as indicated.

The Mattoon Act was not on the statute books when these Holly Street improvement bonds were decided on. The Mattoon Act, however, is now effective, and while the Act has some defects, in this instance it is ideally suited and enables the allocation of charges for improvements in exact proportion to benefit to be derived.

The execution of the project under the 1915 Act would tend to drive away from that district all persons and businesses owning much personal property, whereas under the Mattoon Act such a result would not be produced.

A Course of Procedure Suggested

The Board of Directors of the City of Pasadena is therefore asked to put the Holly Street widening under the Mattoon Act, and to make a scientific study thereunder of the necessary costs and best procedure.

An 82-cent levy was made to care for the costs in this enterprise. This is the last day on which action may be taken to nullify such levy looking toward the substitution of the Mattoon Act for the 1915 Act as a basis of procedure.

Your Honorable Board is therefore requested to modify the ordinance which has been passed and eliminate the 82-cent levy provided therein for this enterprise, pending further action as to placing the improvement under the Mattoon Act.

The Pasadena Board of Directors expressed willingness to place the improvement under the Mattoon Act, and suggested that the matter be carried on as at present planned, and before Jan., 1927, the new plan be worked out by agreement among the taxpayers interested.

That was agreed to, and the problem is now being studied with that end in view.

Mr. Coulston Endorses Survey

J. B. Coulston, president of the Pasadena Chamber of Commerce, and of the Maryland Hotel Company, thus wrote endorsing the survey of the Holly street proposal:

Maryland Hotel Company
Maryland Hotel
Pasadena, Cal.
September 9, 1926.

Mr. C. L. Wright,
Security National Bank,
Pasadena, Calif.

Dear Mr. Wright:—

I have read with much interest the California Taxpayers' Association report on the Holly Street improvement. This is a splendid piece of work and if all of the plans for spending large sums of money in street work or other municipal improvements could receive as much attention and study as this has, a great deal of money could be saved to the taxpayers.

Yours very truly,
(Signed) J. B. COULSTON.

Why Need Flood Control Procedure Constantly Provoke Controversy?

On Sept. 27, 1926, the California Taxpayers' Association, at the request of the Los Angeles City Committee, presented to the Board of County Supervisors, in their capacity as trustees of the Los Angeles County Flood Control District, an important letter, which it is quite generally admitted exposes the fundamental error in the present and past procedure in reference to all or most of the flood control projects. A verbal statement was also made, amplifying the letter.

It was set forth that precipitate action is taken, on such short notice that interested persons—the taxpayers who pay the bills—have no time to examine the proposals and make constructive suggestions to the supervisors, leading to possible harmony.

It was pointed out that, on the contrary, action as now determined leads inevitably to controversy. *A constructive suggestion was made that the supervisors, when bond issues are under consideration, should give the public definite and specific notice and information sufficiently far in advance to enable this constructive course of action to be set in motion.*

At the same time, the supervisors were notified that California Taxpayers' Association, at the request of the Los Angeles City Committee, would make a survey of the flood control district from the beginning of its existence. The courteous cooperation of the supervisors and the employees of the flood control district was requested. The supervisors did grant very courteously access to all records, it being understood that, in procuring them, the researchers would go through the proper channel of authority.

Action in this case was prompted by the announcement late in the afternoon of Sept. 24 that the supervisors would be asked by the Chief Engineer of the Flood Control District to place on the November 2 ballot a proposal for the issuance of $21,193,798 of additional bonds for 21 projects of flood control, and that the matter would be considered by the Board on Monday, Sept. 27, 1926. The letter, signed by Dr. Milbank Johnson, chairman of the Board of Directors, California Taxpayers' Association, follows:

September 27, 1926.

The Honorable,
The Board of County Supervisors
As Trustees of the Los Angeles County
Flood Control District.

ATTENTION: R. F. McClellan, Chairman.

Gentlemen:

The taxpayers of the Los Angeles Flood Control District were informed late on Friday, September 24, 1926, of the proposal by the Chief Engineer of the District that $21,193,798 of additional bonds be issued for flood control and water conservation. The announcement was made that the Board would consider the matter on Monday (today), September 27, 1926. Obviously with one short business day, Saturday, intervening, it was impossible for taxpayers to advise themselves on the subject.

Our Los Angeles City Committee, J. A. Winans, chairman, Edwin Baker, Secretary, had already requested California Taxpayers' Association to instruct its Research Department to make a survey of the Los Angeles Flood Control District from the beginning of its existence. This later announcement emphasizes the need for such a survey, which will be made under the direction of Professor Rolland A Vandegrift, Director of Research.

We have access to the public records; but we would appreciate your courteous co-operation in facilitating a survey by the issuance of instructions from your Board to all employes of the Flood Control District to expedite the finding of the records. This work will begin in the immediate future and will be hastened with due regard for accuracy and thoroughness, and with the hope that constructive suggestions may be made which will contribute to the efficiency and economy of government in Los Angeles County, and, in no small degree, in California as a whole.

We feel that the proposed bond issue is of sufficient magnitude to justify our request that action thereon by your Board be deferred long enough to enable an examination of the proposal, in the interest of those who must pay the bills, namely, the taxpayers.

Precipitate procedure in the past in these premises has given rise to serious controversy. It is our belief that the suggestion herein made

posal might lead to such a constructive course as would avoid controversy over these proposed additional bonds.

An early reply to this letter would be much appreciated.

Yours very respectfully,
MILBANK JOHNSON, Chairman,
Board of Directors.

BOND PROPOSALS INCREASED

The supervisors, however, went ahead with preparations for placing on the November ballot proposals for the additional bonds, announcing, however, that, instead of the sum previously indicated, the total would be $26,887,278, there having been added at the request of the City of Los Angeles, three projects for storm drains—a Sacatela storm drain, $3,285,278; the Slawson avenue storm drain, $2,289,000; the Jefferson street storm drain, $118,630. The 21 projects were:

Western San Fernando Valley, $481,735; Wilson Canyon, $233,979; May Canyon and Pacoima division project, $315,944; Big Tujunga dam, $7,693,500; Haines Canyon project, $334,000; Stough Canyon and Burbank wash, $280,000; La Canada, Verdugo wash and Sycamore Canyon, $2,436,000; Sierra Madre Canyon, $202,200; Sawpit wash, $122,700; Duarte project, $102,580; Fish Canyon project, $18,000; Devil's Gate Dam, $75,000; Santa Monica storm drain, $355,000; Ballona creek, $293,250; West Compton creek, $3,718,330; Los Angeles River, $2,689,830; Lower San Gabriel River, $350,000; Lower Sycamore Canyon storm drain, $227,950; San Antonio Canyon dam, $500,000; Sawpit and Monrovia Canyon, $163,800; Lower Eaton Canyon dam, $600,000.

A verbal statement made on behalf of the Association to the Supervisors said in part:

We respectfully call to the attention of this Honorable Body that this character of procedure inevitably leads to controversy. This is a large engineering project. The public was informed for the first time definitely on Friday, with a short business day, Saturday, intervening, of the matter to come before the Board on Monday, which is today.

There was absolutely no opportunity for taxpayers to examine the proposals, and they are placed in this embarrassing position—they must either take it as it is, or oppose the bond issue.

No one outside an insane asylum of Southern California opposes flood control or water conservation, but there is a large and growing body of influential, responsible and patriotic citizens who are seriously and sternly opposed to the methods of official procedure which make possible waste of tax money.

Why can there not be a constructive method of procedure, one in which the public is taken into confidence, with, say, thirty days' notice, during which time there could be an examination sentatives of those who pay the bills—the taxpayers?

Why need we go on from project to project, inciting controversy, insuring controversy, bringing bitterness, partisanship and acrid debate, when there should be harmony of action, and the bringing to bear of the very best of economic and engineering experience and wisdom which might be found in the community?

We maintain that were a project of this magnitude to be submitted to a well-conducted and successful private corporation on Friday afternoon, with the information that final action must be taken on Monday or Tuesday, the employes and officials who submitted such a precipitate proposal would probably lose their jobs.

It might be said that the taxpayers individually might come from time to time to the flood control district's offices and ask for and obtain information relating to the various projects. That upon its face is an impracticable procedure. There are half a million voters in the district. They hear piece by piece from time to time fragmentary statements that perhaps bonds will be asked for such and such a project, but the first definite, specific statement relating thereto is made on Friday to be finally considered on Monday or Tuesday. It is not good business. It is not just to the taxpayers, and, as we have said, it constantly invites controversy with all the costs of time and money and morale which such a warfare entails.

To Give Youth Better Educational Facilities, Objective of Commission

A study of educational costs in California in the interests of the youth is being made by the Educational Commission of California Taxpayers' Association.

The object is to learn how the youth of the State may be given larger values in educative processes for every dollar expended, and where and how, if possible, costs may be reduced without lessening efficiency. The study has progressed far enough to assure that helpful suggestion will be forthcoming, although the Commission is not yet ready to make public its specific data.

This study was prompted primarily by a belief that taxes were being in a measure collected and expended without full results to the youth. In other words, that there is more or less of waste, which of course does not benefit those who are under instruction.

THE COMMISSION

The Commission is composed of seven, Charles L. Wright of Pasadena, president; Dr. Frank C. Touton, University of Southern California, vice chairman; Dr. William Bennett Munro of Pasadena, Dr. George S. Burgess of Pomona College, Earle Houghton, Strathmore, president of the California Farm Bureau Federation, Miss Louise Clark of Santa Rosa, and Charles K. McIntosh of San Francisco.

N. Bradford Trenham has been selected as secretary of the Commission. Mr. Trenham was elected to represent the State of Arizona for three years at Oxford University, England, under the terms of the will of Cicil Rhodes, South African empire builder, and studied there from 1921 to 1924. In addition, Mr. Trenham studied and travelled in ten European countries during vacations. In 1923 he was the publisher of "The Cherwell" at Oxford, and in 1924 received the degree of Bachelor of Arts, with honors in philosophy, politics and economics.

The following year, 1925, he was research fellow in sociology at the University of Southern California, and assistant to the dean of the School of Education. He has been statistical assistant to the educational secretary, Dr. F. C. Touton, was on the faculty of the University, from which he received the degree of Master of Arts. He is active in educational fraternity work.

Mr. Trenham is in active charge of the work under the direction of the members of the Commission.

THE PERSONNEL

Charles L. Wright, president of the Security National Bank of Pasadena. Mr. Wright is also chairman of the Pasadena Committee of the California Taxpayers' Association.

Dr. Frank C. Touton, Professor of Education, and Educational Secretary to the President of the University of Southern California, is vice-chairman of the Commission. Dr. Touton is well known as an author of educational texts, especially of a mathematical nature, and is one of the best known educators on the Pacific Coast. He is National Vice President of Phi Delta Kappa, educational honorary society. He has also a widespread experience as a school administrator and state official in both Missouri and Wisconsin.

Dr. William Bennett Munro, Professor of History and Government at Harvard University, and perhaps the greatest authority on American local government, is a member of the Commission. Dr. Munro spends the second semester of each year in Southern California, and is as much interested in California problems as in those of Massachusetts. He has written "Principles and Methods of Administration," "Leading Cases on the Constitution," "Government of the United States," "Municipal Government and Administration," "Problems of Citizenship," and a dozen other well known texts on political subjects.

Dr. Geo. S. Burgess, Professor of Economics of Pomona College, is the third member of the trio of eminent professors, interested in educational problems, that the Commission contains.

Earle Houghton of Strathmore, representing the agricultural interests of California, is president of the California Farm Bureau Federation. He became interested in school costs, following the founding of Strathmore Union High School District in Tulare County in 1919, and since that time has sponsored the growth of research in the Farm Bureau, along the lines of educational and governmental costs. He is also a member of the Governors' Agricultural Advisory Council.

The women of California and elected school officials have an able representative in Miss Louise Clark, County School Superintendent of Sonoma County. Miss Clark holds a B. S. degree in Education from Columbia University, two diplomas in Education from Michigan State Teachers' College, and has done several years extension work at the University of Chicago. Miss Clark has been in Europe on two different occasions to study educational conditions and has studied in Asia two years. After her return she spent a year lecturing in eastern and southern colleges on education in Asia. Miss Clark has been County Superintendent for four years, and has spent six years in elementary school work, two in rural school work, two in city, and two in town school teaching. She also has spent ten years in training teachers. Miss Clark not only understands school administration from the point of view of the practical administrator, but has a broad knowledge of and experience in the many problems of government.

Chas. K. McIntosh, President of the Bank of California and Director of the Federal Reserve Bank of San Francisco, has also joined the Commission. Mr. McIntosh is a member of the Board of Trustees of the Santa Barbara Schools, and has a deep interest in the problems of California education.

Demonstration Versus Guessing In Building Flood Control Dams

[Excerpts from an address by the Editor of The Tax Digest before the associated technical bodies of Los Angeles, October 7, 1926.]

This is a thesis to establish:

1. That the additional bond issue of $26,000,000 for Los Angeles County flood control projects, proposed for the November election, should be opposed.
2. That the evidence justifies the taxpayers in demanding that the administration of the flood control district be reorganized, because of apparent present lack of ability and efficiency.

We are entering a newer and better era in which we shall learn how to apply to the benefit of mankind the great mass of scientific information which has been developed in the last 300 years. In preparation for this newer era, every major division of society must undergo and is undergoing a change for the better.

Engineering, perhaps, of all professions, comes nearest to realizing the ideal of modern science; that is, when the engineer is free to work as an engineer, and is not hampered by political restriction. It is a profession of certitude—definitive, accurate, painstaking, inquisitorial, searchingly anxious for facts instead of guesses.

I said during the last 300 years, because it was 300 years ago that Galileo ended his labors, which labors had changed science from guessing into actual demonstration.

For instance, until Galileo reformed science, Aristotle was regarded as the scientific bible of the world, and yet Aristotle declared that the velocity of a falling body was in proportion to its weight. In other words, that if you dropped from the same altitude a ten-pound ball and a one-pound ball, the ten-pound ball would reach the earth quicker than the one-pound ball. But by the process set in motion by Galileo of demonstration rather than theorizing and guessing, it was proven that a one-pound ball will fall as rapidly as a ten-pound ball. So Galileo and Newton and other scientists who came after the great Italian, changed the whole texture of science, as I have said, from one of guessing to one of certitude.

This is the philosophy of the engineer of today. When he is given a free hand. when he may go out in this searching inquiry after facts, he will bring us the facts, and we will be safe in following his guidance.

Every engineer knows the truth and dignity of these observations. I wish frankly to call attention to a growing danger to the engineering profession by the substitution in some instances of political policies in the place of engineering scientific investigation.

We have in contemplation and in partial execution, vast engineering projects inrado River and its development and control, for which every sane person is anxious, and which will involve, together with the aqueduct which Los Angeles and other cities will utilize, more than $500,000,000 of capital commitment; yet, today, because it has been taken into the political field, and some persons by fear are stopped from rational discussion of cost and engineering, the public at large, who must pay the tax bills, are thinking of Colorado River Development in terms of $125,000,000.

Were there utter freedom from political complexity, these engineering and cost facts would by this time have been brought vividly to the attention of the people, so that they would know precisely to what they were asked to commit themselves. Doubtless they would commit themselves, even with the facts in their possession. But it remains true, nevertheless, that the full facts are not being given to the people, and because politics has entered into the proposition.

Coming to flood control. In the Los Angeles Flood Control District, $39,800,000 of bonds have been voted, and more than $26,000,000 are to be asked for in November; an aggregate of more than $65,000,000, and the end is not yet. It is officially announced that other requests for flood control bonds will be submitted to the people in the near future.

I submit that enterprises of such magnitude call for the most scrupulous care and the most searching preliminary investigation prior to asking for any such commitments, and the same was true before the $35,300,000 of bonds already voted were placed upon the ballot.

The list of flood control projects was made up and the money allocated therefor largely by political request of the people in a given locality, without careful hydrographic, engineering and economic studies as the base thereof. Instead of going to the engineer first and saying: What are the conditions in such and such a canyon? What are the hydrographic facts? How much storage capacity is needed to control and conserve the water there? What is the geological formation, and how deep need we go to get a firm foundation for a dam? And then, How much money is necessary to effect these results? There is

place, and more or less of a guess as to how much money is needed.

If $25,000,000 is allocated to a given dam—the San Gabriel, for instance, it may be too much; it may be too little. In any case, if it be a guess, it is unscientific, repugnant to practice and ethics, unfair to the public, destructive of confidence in government and the remainder of the engineering profession, brings sneers and flings from the mass of the people, and opens the door to possible, almost inevitable, wastes of taxpayers' money.

The record is that the $35,300,000 of bonds allocated to the San Gabriel and other flood control and water conservation dams was not a resultant of exploration and investigation by core drillings and tunnelings, and hydrographic and economic studies, such as are necessary to a determination of the exact needs in a given case. There was in that instance a reversion to the guessing of Aristotle, apparently. By later evidence we find that this $35,300,000 guessing was just as far from the truth as Aristotle was when he guessed that a ten-pound ball would fall faster than a one-pound ball. So-called estimates are woefully out of alignment with later actual costs.

The official statement of the Flood Control District gave an estimate of excavations for three dam sites, 22,000 yards at Pacoima, 22,000 yards at Big Santa Anita, and 22,000 yards at Sawpit.

In the light of the revised estimates at this time, it is absolutely proven that these estimates of 22,000 yards were not true estimates at all. They were mere guesses. On the Pacoima Dam, instead of 22,000 yards of excavation, more than 100,000 yards have actually been paid for, and the excavations running into the abutment bases would add something like 20 per cent to this total, so that in the neighborhood of 120,000 cubic yards will have been excavated at Pacoima, making the original 22,000 yard so-called estimate an absurdity on its face.

One might multiply these instances, but in any event he would arrive in practically every instance at the same conclusion, namely, it was a process of guessing, and not a process of scientific determination by well settled rules of engineering.

Revert to the San Gabriel dam; $25,-

acre foot reservoir. Four million yards of concrete must be poured; a railway 11 miles long must be built and equipped; spillways, gates and appurtenances must be provided; rights of way must be bought; labor must be paid; materials must be bought, with a thousand and one other items of expense in construction of such an edifice. Is there anyone here who, in the light of broad experience in concrete construction, will say that four million yards of concrete may be poured at less than $7.50 a ton, all costs included? That would bring the cost to $30,000,000, but we know also that, in the light of experience, $8 a yard as the unit cost is safer, which would bring the cost to $32,000,000.

Here is a discrepancy of around $7,000,000 between the cost of a 240 acre foot dam and reservoir as indicated by experience, and the amount allocated thereto, $25,000,000, by the Flood Control District.

On a basis of 4,000,000 cubic yards of concrete, the Flood Control District would have to pour it and provide all the other items of expense on a unit basis of about $6 a yard. I obtained from the United States government figures on a dozen dams of various sizes. The average was more than $12 a yard, all costs included.

Have we any evidence that there is such a super engineer in the Flood Control District as could reduce the unit cost on the San Gabriel dam to 50 per cent of the average cost on this dozen dams of similar character which have been erected by the United States government?

Can the San Gabriel dam be built for $25,000,000 in the light of these facts?

In the case of these other dams, they were carefully explored; there was outside consultation; there was a comparing of notes; there was every evidence of anxiety by those on whom was the responsibility that the final result be agreeable with engineering rules.

I submit that these things justify the voter, anxious as he is, for the full solution of the flood control problem, to oppose the $26,000,000 bond issue which will be on the ballot November 2 for flood control; to insist that further studies be made and that independent advice be procured. All this matter leads us to the fair though serious conclusion that complete reorganization of the administration of the Flood Control District is the only basic solution of this large problem. There should enter into such conclusion no element of prejudice and it should be devoid entirely of personalities. Bitterness, prejudice, unfair statements, half truths and mere implications do not lend themselves to a judicial conclusion, but we are dealing with a serious subject. Each voter is a trustee of his own and others' rights in such matters, and especially is this of interest and perhaps a larger duty to those who are technically trained and who understand how to demonstrate rather than guess in such proceedings.

Grange President Makes Taxation Economy Plea—Advises Scrutiny of Bond Proposals

The Tax Digest is obligated to Geo. R. Harrison, Master of the State Grange, for the manuscript of his address before the 54th Annual Convention of the Grange at San Jose, Oct. 19, 1926. His position coincides with that of California Taxpayers' Association. His address in full was:

By GEORGE R. HARRISON
Master, California State Grange

The Grange in California today occupies a position of importance and influence entirely out of all proportion to its membership. This place has been achieved and may be maintained only by the possession of a broad knowledge of public affairs, by dispassionate and calm consideration of agriculture's problems, and by the adoption of a courageous and forward looking policy of SERVICE, not only toward those engaged as we are in farming, but all of the other industrial and commercial groups of the state. Our farmers must remember that they are a part of this great commonwealth and that their reasonable well being is necessary for the best interests of all of the citizens of California, but in working out OUR destiny we must not forget the rights and necessities of others.

Within the last year, our membership has shown a substantial increase, and this has come about almost without effort upon the part of our state organization. We believe, however, from the requests which are coming to us from parts of the state where we at present have no local units, that during the coming year we should make an effort to organize subordinate granges in those places where grange interest is keenly aroused and a definite demand being made for grange service.

The farmers of California, in common with those of the other states of America, have upon many commodities and in a great number of widely separated localities, suffered an inadequate financial return as a result of the sale of this year's crops. Our present system of distribution of farm products is antequated and wasteful. The fact that only about one-third of the consumer's dollar ever reaches the farmer producer proves this. In the interest of both producer and consumer the system of distribution must be largely revised.

Cooperative marketing organizations, if properly administered, will greatly help, but agricultural finance must also be considered as a matter of primary importance. Whatever is done to remedy the defects of the system of distribution of agricultural products and the financing the movement of them to retail stores, must be worked out only after a calm consideration of as many of the pertinent facts as a comprehensive research can ascertain.

The recent publications of the economic research division of the U. S. Department of Agriculture show that, in the six-year period 1920-1925, the farmers of America earned about *one half* of one per cent net upon their investments.

The reward for labor and managerial services of the farm operators of this nation during this period averaged slightly less than $500 per year. During these six years the investment of the farmers of this nation suffered a shrinkage of perhaps seventeen billion dollars or about 20 per cent.

From the peak post-war prices of 1919 the value of farm products raised annually (at the ranch) have declined over three billion dollars or approximately 20 per cent.

The taxes paid by the operator upon his investment in farm property take over twice the portion of his net return which was required to meet this charge in 1919. So much for the national situation of Agriculture today.

If we look into the facts as they are reflected by statistics covering California only, we may be surprised to find that, while the value of farm products in the United States increased during the period 1913-1924 but 60 per cent, those of this state increased over 250 per cent. California's farmers, in the aggregate, today are cultivating intensively but little more land than they did forty years ago, but their individual acreage so used has declined about 66 per cent within this time.

Our California farm operators who have increased in number about 225 per cent during the last forty years, have gradually taken the land which once produced the great staple crops and have put it into the raising of the agricultural specialties for which this state is so famous. This very development, however, has added to their indirect burdens. From the figures furnished by our state comptroller we find that during the ten-year period 1914-1924 the assessed valuation of property outside of our incorporated cities and towns increased about 93 per cent, as against only 66 per cent for inside property.

During the eleven-year period 1914-1925 the expenditures of the state of California and its political subdivisions increased about 285 per cent, the outstanding bonds increased about 19 per cent and the creation of new wealth increased about 120 per cent.

These figures seem unquestionably to show that our farmers cannot escape carrying a very much larger portion of any increase in taxation than their earning power justifies. Farmers everywhere labor under the fundamental disability, as do all other producers of primary wealth, of being unable of passing on practically any of their taxes. This disability perhaps is most accurately reflected in the figures published by our Federal Department of Agriculture, which show that the net earnings of our average farm operator have declined about 30 per cent since 1919, while our factory workers are enjoying returns for their labor practically equal to those peak post-war years.

That taxation has outrun all bounds of reason in this state may easily be shown by considering certain districts. Perhaps the worst of any sections, from an agricultural viewpoint, is that around Blythe in Riverside County. There in the Palo Verde District the rate is about 36 per cent on an assessed valuation supposed to be about one-third the value. As a matter of fact under such a frightful tax burden this year about one-third of the taxes are going delinquent. The county of Riverside, which is essentially a farming district as far as its development has gone, has shown a growth in tax delinquency starting at 5 per cent in 1918 and increasing to 11 per cent in 1925. A lack of time forbids the citing of other instances of economic suicide via the tax route. The recent organization of a state-wide Taxpayers Association in California, in which it is hoped that our farmers will actively function, is a most encouraging sign that some groups other than agriculture are becoming awakened to the alarming tendency of ever increasing public expenditures and the expansion of governmental activities along lines undreamed of by the founders of this nation.

BATTLE OF THE GRANGE

The battle of the Grange in this state today is upon the identical ground and for the same purpose which consumed the attention of its founders in California over half a century ago. Either farming as a means of earning a livelihood must come upon a permanent parity with other industry and commerce, or those who produce the food and clothing of the human race from the soil must sink (as they always have done in the past) to the lowest stratum of organized society, and the American Farm Home, as we have known it, become a memory!

Let us accept the gage of battle and at once resolve that all of those measures which are today before the electors of this state upon the ballot will be carefully scrutinized by us and those which would further increase the economic disadvantage of our farmers shall suffer overwhelming defeat at the November election. Our State Grange Lecturer has caused a statement of facts upon each, which is of great interest to us farmers, to be broadcasted through the September issue of our State Grange Bulletin, to the proper officers of every grange within California. We hope that you have followed the admonition of our State Lecturer and that you have read these carefully prepared statements, in your grange meetings. You may be interested to know that the other state-wide farm organizations of California followed a similar course, with the result that these amendments and legislative proposals which affect us farmers will have been discussed in over 1000 farm meetings in this state before the day of the election on November 2.

In conclusion, let us not forget that any proposal which calls for increased taxation should be looked upon with great suspicion as being inimical not only to our interests but to those of the citizens of the state as a whole at this time, and that any effort to increase exemption from taxation must be combatted by us with every means within our power. In this movement we are allied with the other farm organizations of California.

Let every member see to it that the Grange declares ONLY for true agricultural principles and then throws all the weight of its influence to enlist every farmer in this state to the support of a CONSTRUCTIVE program, and to win also, because of its justice and necessity, the approval of all right thinking, fair minded and patriotic men and women, all true Americans, regardless of race or place of birth. Let us all diligently labor for the good of Mankind, our Country and our Order.

Petaluma Grange Commends the Association

At the meeting of the Petaluma Grange, after considerable discussion relative to matters of taxation in this county, the grange by motion unanimously commended the California Taxpayers' Association and its president, A. C. Hardison, in sending into this county the research men and tax councilor who made a thorough investigation of this county's affairs and who have already submitted their preliminary report to the County Board of Supervisors. The final report will be submitted within the next few weeks.—*Petaluma Courier.*

Industrial Council Endorses Economy In All Appropriations By Legislature

A policy of conservative and careful expenditure of the public funds to encourage the further development of California, was endorsed by the California Industrial Council, which met in its sixth conference at Oakland Sept. 26. A resolution adopted by the Council was as follows:

WHEREAS, The development of California will be encouraged, the prosperity of its citizens will be increased, and the attractiveness of the Commonwealth to men and capital now beyond its borders will be enhanced in direct ratio with the maintenance of a fair and equitable system of State Taxation, subject to the least possible change, and with adherence to a policy of conservative and careful expenditure of public funds, therefore be it

RESOLVED, That the Advisory Committee of the California Industrial Council earnestly urges the members of the next State Legislature to reject any and all proposals for changes in the present tax laws of the State which would result in unfair or unjust levying of taxes on one or more classes of property to the advantage of other classes of property; and the Advisory Committee expresses the profound hope that said State Legislature during its next session will refuse appropriations for all unnecessary purposes, and hold all appropriations made to minimum sums necessary to meet reasonable requirements.

The Council also voted to oppose the $500,000,000 water and power bond act proposed under initiative for the Nov. 2 election.

At the meeting in Oakland, Vance H. Evans, executive secretary, California Taxpayers' Association, spoke on the purposes of the Association, and took an active part in the proceedings of the day.

National Tax Association to Meet In Philadelphia

The National Tax Association of the United States will meet in the 19th annual conference in Philadelphia, Nov. 15 to 19, with headquarters at the Benjamin Franklin Hotel. Governor Gifford Pinchot and Mayor W. Freeland Kendrick will speak. Papers will be read by various tax experts, among whom will be C. E. Arney, Jr., executive secretary, Federation of Taxpayers' Associations of the State of Washington, on "Suggestion for the Control of Public Expenditures," and Ray L. Riley, State Controller of California, on "The Elimination of the State Levy on Property as a Part of the Tax Program, from a California Standpoint."

Dr. Johnson and Prof. Vandegrift will represent California Taxpayers' Association.

Widows and Children to Pay Because Foreign Securities and Solvent Credits Were Not Listed

In an interview, Ed W. Hopkins, assessor of Los Angeles County, speaking of the new personal property law—the foreign securities and solvent credits taxation law—said:

The only objection I have heard is from those persons who did not file their statements. It is rather sad to know that many men, and there are hundreds of them who have died since the first of July and have exposed their holdings through inventories filed of their estate, did not realize the importance of listing their holdings, and now the widows and children are compelled to pay fourteen times as much in taxes as they would have had to pay had this class of property been properly listed to the assessor along with their other holdings.

Mr. Hopkins was asked to give a general survey of the operation of the foreign securities and solvent credits law, and, in addition to the foregoing, said:

The operation of the law this year was a great success, notwithstanding the fact that the combined net assessed value of solvent credits and stocks and bonds was under that of last year.

It appears, so far as the solvent credits were concerned, that the law was little understood.

Many financiers and lawyers expressed surprise that solvent credits were included in the provisions of the law, yet that is the fact. We did lose in valuation on solvent credits. Heretofore, the solvent credits that we have assessed have been obtained principally from business houses whose books we had an opportunity to examine. Practically all others escaped, and it was working a hardship upon the few from whom we had exacted this assessment.

I believe, however, and it has been the history of similar laws in other states, that this item will gradually increase year by year, and within four years, before I finish my next term, that I will get at least ten times as much valuation out of this class of property as we did prior to the enactment of the new law.

With foreign stocks and bonds, the report is very much better. Last year, in round numbers, the assessed valuation of this class of property was $17,000,000. This year it has reached over $26,000,000. I am speaking now of net assessed values, and not gross values. We had the splendid co-operation of the different stock and bond houses, as well as some of the financial companies. Each year, I am sure, this valuation will be increased as the provisions of the law become better known.

The new law has had a good effect on people who had heretofore claimed a residence in other parts of the United States, although this was in fact actually their residence. I could cite several very notable persons, but do not care to mention names. I feel that the law is a great success. It has given the owners of these classes of securities a much better feeling toward the State, and in the future many of the very rich men of the East who expect and intend to make this State their residence will bring with them all of their securities and make this their legal residence.

I trust that the Legislature will not change the law in any particular. At the State Assessors' Association this year there was no complaint about the law, and all seemed satisfied.

California Taxpayers' Association urg all citizens to make full return of th foreign securities and solvent credits und the operation of this new law, which pr vides that such property shall be assess at 7 per cent of its value, instead of at per cent of its value, as is done on average in assessing other prop throughout the State of California. To assessed value of 7 per cent, the tax rate is applied, so that those who due return and observe the law, pay actual taxes only one-fourteenth as as they are required to pay if they do make the return to the assessor of property and it is discovered by the sessor, as is the case in many inst When he discovers such property not turned to the assessor, he is, under the compelled to assess it at 100 per cent the tax rate applies thereon.

California Taxpayers' Association out 100,000 digests of the law through vestment bankers, bond houses and fin companies, and there was extensive planation of the law in the newspapers well as in The Tax Digest.

The striking feature of Mr. Hopkins' terview is that the death of many citi has disclosed foreign securities and sol credits which had not been listed with assessor, and that therefore the widows children inheriting estates must pay fo teen times as great sum as the test would have paid in taxes had there bee proper listing of the property.

It is encouraging that Mr. Hopkins, has had such wide experience in asse ment and whose judgment in the premi is generally accepted as sound, regards operation of the law, on the whole, as great success, and predicts that by time his present four-year term shall ended, the actual return from Los Angel county in tax money on foreign securit and solvent credits will be many times much as it was before the law was pa

The

TAX DIGEST

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NUMBER 2

FEBRUARY 1927

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Federal Tax Facts

In 1925, the amount of government taxes on the Class 1 railroads of this country was equivalent to more than six and one-half times as much gold as all the gold mines of the United States and its possessions produced during the year. Since 1911, railroad cash dividends have shown a decrease of 14 per cent; railroad taxes have increased 263 per cent.

During the fiscal year 1924-25, the interest-bearing debt of the United States Government was reduced by some $827,000,000. While there were certain tax reductions, the total yield of income was increased; government expenditures increased a little over one per cent. During this time, the Nation reached its highest annual mark in foreign loans, foreign capital issues publicly offered in the United States amounting to $1,382,000,000.

The Department of Commerce reports that the "investment" by the American taxpayer in the foreign trade promotion work of the Department of Commerce, involving an annual appropriation of about $3,000,000, was returned more than sixty-fold during the fiscal year 1925-26 by the new foreign business secured for individual American exporters as a direct result of the assistance of the Bureau of Foreign and Domestic Commerce.

The National Industrial Board after an exhaustive study of government cost, states that 8.1 per cent of the income of the American people goes to Federal, state and local employes, and for public charges. In other words, the annual cost to each non-government worker as his share in support of government expense is $126. Another startling discovery made by the Board is that in 1924 the amount paid to government employes and for public charges was 37 per cent of as much as was paid in wages and salaries by all the manufacturing plants of the country the previous year.

Mitchell B. Carroll, Division of Commercial Laws, Department of Commerce, reports on the "revised System of Taxation in Italy." It is a very thorough study of the new system which abolishes war and postwar levies, and has reduced direct taxes, with alterations, to the three original levies on income from land, buildings, and movable wealth, superimposed in the case of individuals, by a complementary income tax with progressive rates. The tax of 15 per cent on dividends has also been abolished, but such revenue is subject to the complementary tax when the holder is resident in Italy.

Walter J. Greenleaf, Interior Department, Bureau of Education, has compiled statistics showing that $79,011,421, or 51 per cent, of the total incomes of state universities and colleges in the United States is expended for salaries and wages; 23 per cent for materials and supplies; 14 per cent for lands and buildings, and 4 per cent for equipment; the other 8 per cent goes for miscellaneous expenses.

Californians are interested in the fact that of all state universities and colleges, the largest amount for salaries, $5,804,557, was expended by the University of California. The University of Michigan expended the largest amount for supplies, California ranking second; Michigan expended the largest amount for permanent equipment.

Tax and Economic Truths

A reduction of the number and forms of taxes will do more to bring factories into town than signboards down at the depot.—*Lorain, Ohio, Journal.*

What observer of government in action expects a tax law to bear no marks of politics? Too often, everybody concerned in the making of such a law plays politics.—*Ohio State Journal.*

Taxes, unless confiscatory, must come out of annual income or net production. The smaller the amount taken in taxation, the greater the amount left for the taxpayers' own use and the greater the amount that is likely to be added to the productive capital of the country. The amount of capital available for productive enterprises has a direct bearing on the prosperity of a country with large undeveloped resources.—*Canadian Taxation.*

President Coolidge before Federal Budget Conference:

The Federal Government has strayed far afield from its legitimate business. It has trespassed upon fields where there should be no trespass. If we could confine our Federal expenditures to the legitimate obligations and functions of the Federal Government, a material reduction would be apparent. But far more important than this would be its effect upon the fabric of our constitutional form of government, which tends to be gradually weakened and undermined by this encroachment. The cure for this is not in our hands. It lies with the people. It will come when they realize the necessity of state assumption of state responsibility.

It will come when they realize that the laws under which the Federal Government hands out contributions to the states is placing upon them a double burden of taxation, Federal taxation in the first instance to raise the moneys which the government donates to the states, and state taxation in the second instance to meet the extravagance of state expenditures which are tempted by the Federal donation.

The Chief Executive may preach economy, but, unless the people in the service practice it, the preaching is in vain. There are still reductions to be made. There are yet wastes to be eliminated. I expect you to prosecute a campaign of relentless economy to that end.

Sacrifices will be required. I want to see the sacrifices of those who are charged with the expenditure of the money of the government somewhat commensurate with the sacrifices that have to be made in the home by the taxpayers who furnish the money for government."

The TAX DIGEST

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Happenings of the Month

THE Apostle Paul said: "I am a citizen of no mean city." Likewise, C. C. Young, who on January third was inducted into office, could say in pardonable pride:

"I am now the Governor of no mean Commonwealth! A Sovereignty of more than 150,000 square miles of area—thirteen and a half times the area of Belgium, three times the area of England, three-fourths the area of France, and almost the area of Germany. A Commonwealth which for three-fourths of a century has been of the United States. A Commonwealth, the history of which runs back nearly four centuries to when Cabrillo landed on California shores in 1543. A Commonwealth with four and a half millions of population."

Thus he might speak, as doubtless he thought, when he took over from the capable hands of Friend W. Richardson the gubernatorial authority at Sacramento.

It is not a trivial event when California changes Governors. It means the transfer of large powers. Equally, it means on the Governor's part the assumption of large responsibilities. An elected and inaugurated Chief Executive resembles not at all a citizen as a candidate. Then he was asking of the voters. Now he must return something to the voters—redeem his pledges, or be false to all standards of sociologic and political decency.

The Pasadena Star-News thus states the proposition: "Governor Young has outlined a forward-looking, constructive, businesslike program," and goes on to commend the Governor for pledging the square deal for all legitimate business.

ALL this is pertinent to these columns because in his inaugural, Governor Young made several specific references to taxation and administrative issues which are vital.

We accept the Governor's purpose as commendable, and as based on his conception of that which would make for the public weal. He is an honorable man, and a patriot.

THE Governor has announced his policies. Let us at the moment concern ourselves with only those which are basic. Governor Young declared for "an economical administration," the creation of a commission to examine California's taxation system, "consolidation of various groups of independent boards and commissions," "unification of governmental functions," and "the creation of a Governor's cabinet or Council, composed of heads of departments who shall meet regularly with the Governor to discuss the various problems confronting the State."

In so far as concerns unification, consolidation and a Governor's Cabinet, these proposals are almost exactly what Frank O. Lowden as Governor of Illinois during the war proposed, and finally made actual as shown by Gov. Lowden in THE TAX DIGEST of November, 1925, page 33. They resemble that which is laid down as its objective by the New York non-partisan commission on state governmental reorganization, a statement on which appeared in THE TAX DIGEST of February, 1926, page 57.

THESE declarations are important, California, in common with many if not most of the States, has multiplied these boards until government, in some respects. has become just one state board action after another, often to the point of inefficiency by reason of too great complexity and sometime perhaps meddling.

If a simpler, more unified form of government be devised, if the trouble be attacked at its root, if thereby waste, useless expenditure of the taxpayers' money, and unnecessary interference with the legitimate freedom of private effort be lessened, the realization of Governor Young's reorganization proposals will be immensely beneficial to California.

Governor Lowden, largely through reorganization, actually reduced Illinois taxes during the war, when other states were carrying a heavier tax burden.

Reorganization alone, if done wisely, would enable tax reduction, besides increasing governmental efficiency. There is therefore no ground for claiming that necessarily taxes in this state need be increased, either in their rates or volume. They can be reduced—and reorganization supplies the opportunity.

ONE measure—uniform budgeting by political subdivisions — will aid towards economy. A bill for an act providing for such budgeting by counties has been drafted by California Taxpayers' Assocation through the Tax Counselor, M. D. Lack, and has been introduced in the Legislature by Senator Frank S. Boggs, of the Tenth Senatorial District, Stockton.

This bill has been most carefully drawn, has been approved by the Board of Directors, and should be enacted. The text of the bill is to be found on Page 64 et seq. of this issue.

It is commended to the attention of the Governor and the members of the Legislature.

MAY the new Chief Magistrate prosper; may he perform so that, through the four years of his incumbency, he can hold as he now has the kindly thought of the people of California.

THE TAX DIGEST issues this month from its new quarters—Suite 775, Subway Terminal Building—and invites all taxpayers and especially the members of the Press, to call. They will find California Taxpayers' Association in much larger quarters, every square foot in intensive use, and *every member of the staff genuinely busy.* A year ago, the Headquarters staff numbered six; today, twenty; and it has not yet attained full growth. Besides, there are a dozen well organized local county committees, and another dozen will be organized in the immediate future.

Eventually each of the 58 California counties will have its local committee. There is encouraging news from the field, and efficient work of organization.

The work of research goes on, too, with increasing efficiency, and will during 1927 be greater than ever before. Several important surveys will be made during the year.

From the Department of Tax Counselling, communities are receiving valuable assistance. This is in the nature of "follow up" work, to crystallize and apply practically the results of surveys by the Research Department.

A new department has lately been added to THE TAX DIGEST activities. Fred D. Fenn has taken hold vigorously of promoting the circulation of the magazine, and is getting results.

THE members of the staff have lost no time in squaring away for a year of better work in 1927 than in 1926, fruitful as 1926 was. The original high purpose of the Association was again clarified for the staff when, at holiday time, Dr. Johnson re-stated the one motivating thought—

To induce a reduction of taxes for all taxpayers of California, large and small; to pull no special interest chestnuts from the fire; and to labor for efficiency of government.

A "long pull, a strong pull, and a pull all together," is the slogan, and it is exemplified by every member of the staff, by unity and intensive individual effort for the common good—"*To put more sense in the California Tax Dollar.*"

W. E. MORGAN, assistant State Superintendent of Public Instruction, writes from Sacramento: "Our attention has been called to the report made under your direction concerning elementary schools in Sonoma County, and published

THE ORIGINAL SLOW MOTION-PICTURE

—Gale in the Los Angeles *Times*.

in THE TAX DIGEST. This study has been commended to me as one containing valuable data on unionization. I would like a number of copies of this report."

THROOP MEMORIAL CHURCH, Pasadena, conducted a course of eight "Citizenship Lectures," from Dec. 5 to Jan. 30. *Of the eight subjects, six were on taxation.* The lecture on Dec. 19 was by Prof. Rolland A Vandegrift, Director of Research, California Taxpayers' Association, on "Costs and Methods of Financing Public Improvements." The subject of taxation is taking powerful hold on the public imagination. The fact that a well-conducted church such as Throop Memorial gives such marked attention to it, is significant, indeed. It is in a large degree *the* topic of the day in California and throughout the Nation.

J. F. GRAHAM, principal, Lemore Union High School, manifests interest in the recent article in THE TAX DIGEST on "Better Education for Sonoma County Youth at Less Cost," and requests a copy of the full Sonoma County report of California Taxpayers' Association. Mr. Graham is one of many who have shown keen interest in the Sonoma County survey, which has gained fame as a good work of research, based on the constructive thought of economy in government with increased governmental efficiency—or, in brief, "*getting more sense in the California tax dollar.*"

CALIFORNIA TAXPAYERS' ASSOCIATION has received from F. N. Fletcher, Director, Nevada Taxpayers' Association, National Bank Building, Reno, a request for the Sonoma County report Number Two, Mr. Fletcher writing: "I hope the (Nevada) Legislature will make it possible to have some such work done in Nevada, and shall use your reports before committees on education to show what should be done."

THE National Education Association of the United States is reaching across the continent for the research material of this Association. John K. Norton, Director, writing from the Education Association's headquarters at 1201 Sixteenth St., Washington, D. C., says:

"We have just received copies of the survey recently completed by your Research Department, dealing with Secondary Education in Sonoma County, and appreciate your kindness in keeping us in touch with this material. We will look forward to receiving copies of additional surveys which are prepared by your organization on the subject of education."

GOV. JOHN HAMMILL of Iowa has asked and received from the Research Department, taxation information relating to California and other states. The request is one result of contacts at the National Tax Conference in Philadelphia when California Taxpayers' Association was represented by Dr. Milbank Johnson, chairman of the Board, and Prof. R. A Vandegrift, Director of Research. By the way, they brought home some compliments by eminent national taxation authorities for THE TAX DIGEST, as "*the best taxation magazine in the world—the one which, while technically accurate, translates taxation into human terms understandable to the man in the street.*"

THE national debt was reduced $1,173,504,301.08 during the calendar year 1926. Under Secretary of the Treasury

G. B. Winston estimates that the current fiscal year ending June 30, 1927, will show a surplus of $383,000,000. The Index, published by the New York Trust Company, discussing the question of the proper and the possible ways of disposing of surpluses, lays down a principle in the form of the following observation which is worth careful consideration: "Tax reduction applies not to one year, but to every year after its adoption. Surplus is a casual happening, occurring in one year and not in another. A loss of revenue which could be easily sustained in the fiscal year 1927 might result in putting the budget in the red in 1929 and require the imposition of additional taxation."

PROMISE of economies in the construction of flood control, water storage and irrigation dams is held out by the experiments made at Stevenson Creek, near Fresno. The Engineers' Foundation conducted the experiment—the construction of a dam, to test the flexibility and resistance strength of concrete. The dam is 140 feet at the top and 60 feet in height. At the base it is only seven and a half feet thick, and at the 30-foot level it was thinned to two feet, which thickness was maintained for the remaining 30 feet to the top. The dam was built without reinforcing steel. It was expected that the dam would break.

The experiment was to determine at what stage of water pressure the break would occur. *But the dam did not break.* Not even when there was a flood which poured over the top of the dam was it injured.

Prof. Charles D. Marks of Stanford University is chairman of the committee of engineers which conducted the experiments.

The cost of the dam, $110,000, was met by various power companies, bankers, engineers and technical bodies. It is proposed to raise the dam to a 100-foot height, to continue the experiment.

It is an experiment of immense value to the world, and the taxpayer is interested, inasmuch as the experiment indicates the probability of vast economies in the construction of public works. Immediate practical results of course may not be possible. Before putting these discoveries and demonstrations to actual use, there must be thorough working out of the technical details, and perhaps further experiments may be necessary. However, literally the engineering world, American and foreign, is watching the experiment, and the best brains in the profession are engaged in the work.

Such service to the public as the engineers are giving in this case is deserving of commendation. Final success of the experiment to the point of demonstration of certain definable stresses and resistances, beyond what have heretofore been held as the norm, will enable large savings and by that much benefit the people. The taxpayer will, therefore, cordially and gratefully give these public spirited and able engineers a "diploma *cum laude*" in the college of public interest and economy.

THERE have been many statements in the public press relative to the position of California Taxpayers' Association and THE TAX DIGEST in the San Gabriel flood control controversy. Frankly, almost every statement has been inaccurate, although we are sure that in nearly every instance there has been no intention to misstate. To clear the air, now that the board of three engineers is at work on an unbiased study and report, THE TAX DIGEST cites:

We have never "advocated the Granite Dyke site as against the Forks site," or any site as against any other. We have only asserted and now assert that "no one ever could know which of the sites or which of the many plans suggested is the best until the usual study of the economic, engineering and geologic phases and physical exploration should have been made in an unbiased manner by competent experts."

The first declaration was made in December, 1925, by us, that:

"The further examination of the available sites for the San Gabriel River flood control dam *appears* to be, not only necessary, but sternly demanded, in the light of the facts herein set forth."

In January, 1926, the headline over the San Gabriel article said:

"Why Not Sink All Differences to Learn San Gabriel Facts?"

In February, 1926, we restated the position as:

"*To ascertain whether or not* the results desired (adequate flood control) could be attained by modifying the plan and thereby saving many millions to the taxpayers without impairing the efficiency of the enterprise."

The Fluctuation of the French Franc

The Humor of the Cartoonist

THE FRENCH FRANC IS FALLING FAST!
MON DIEU! I AM RUINED!
FRANCE IN JULY
THE FRENCH FRANC IS RISING RAPIDLY!
MON DIEU! I AM RUINED!
FRANCE IN NOVEMBER

IT GETS HIM GOING AND COMING!

—Gale in the Los Angeles Times.

The Seriousness of the Financier in Paris

"Haste make waste, waste makes want," is true generally, it is true particularly in a case of attempted escape from the almost countless evils, actual and imminent, of inflation. When the franc, for example, is going down, capital is vanishing, and holders of French ready money or its equivalent are distressed and alarmed. When the franc, on the other hand, is going up, especially if it goes up too rapidly, holders of French securities dependent upon industrial prosperity are likely to cry out or rush to sell; they fear the partial or total loss of their dividends. Hence, once your money has soared away from the gold standard you must use caution in bringing it back to that basis, lest you plunge your industry and finance into chaos.—*Jacques Seydoux, Under Director of French Foreign Affairs.*

It is extremely unfortunate that there has been a rather constant misapprehension on the part of some persons by reason of these apparently unintentional misstatements. The present course of procedure, which is ideally calculated to bring a final and desirable result, would long since have been adopted, had there been a public understanding of the real issue involved.

THE TAX DIGEST takes the position at this time that it would not be graceful to review the controversial features. Therefore, in absolutely good feeling and confidence that the outcome will make for efficiency and adequacy, we await the study and report of the three eminent engineers who are now at work upon the problem.

Let no one pay heed to the silly intimations that anyone who is sane desires to prevent adequate flood control. The proposition is too absurd for any sensible man to waste time debating it.

On page 58 of this issue we print the later developments in the San Gabriel matter.

PROF. T. W. HART, Department of Education, University of California, has asked for 25 copies each of the Association's report No. 1 and No. 2 on Sonoma County, and writes: "They are to be used in instruction, lecture and survey work in the state." Prof. Hart's request has been gladly complied with. Indeed, the Association hopes it will be understood that these and other reports are for widespread use, to aid in analyzing taxation costs in California.

GEORGE C. JENSEN, Director of Research, California Teachers' Association, in the Sierra Educational News, (received as we close our forms,) writes an article captioned "Attack on California Schools Exposed, a Reply to California Taxpayers' Association's Report on Sonoma County High Schools." There is not space this month, nor time in which to take up in detail Mr. Jensen's article. However, Mr. Jensen at the very beginning reveals the fundamental error in his thesis. He says:

> It is axiomatic that any organization, having as its slogan "Taxes shall be reduced," cannot enter scientifically upon any investigation involving public expenditures. The very essence of all proper and scientific investigation shall be no pre-conceived conclusion to bias the investigators.

No question could be debated unless there were some common premise or premises on which the antagonists were agreed. When Gallileo proceeded to overturn Aristotle's theory as to the velocity of a falling body, he assumed the law of gravity. No sane person would have required him to prove the law of gravity every time there was a discussion which involved it. And so in every discussion. There must be some common ground, some premises, otherwise. argument would be useless and impossible, and would run to endless length.

Every time Mr. Jensen dealt with figures, as a research man, he would not stop to prove that four times four equals sixteen. He would assume that all intelligent persons admit that fact.

Now as to the assumption that taxes are too high. It is a fact which has become axiomatic. Economists worthy the name admit it, and public officials, business men, farmers, small taxpayers, and home owners. It is a fact which forces itself on the public consciousness, and becomes, as we said, axiomatic.

We quote from Governor Young's inaugural:

> To do this would inevitably lead to the necessity of imposing a state ad valorem tax on our citizens *already suffering under too great a burden of local taxes.*

Will C. Wood, in the thirty-first biennial report by him as state superintendent of public instruction, said:

> There is therefore a demand, and a proper demand, that every unnecessary public expense be eliminated and that expansions in governmental works be curtailed so far as possible. *In the light of the demand for reduced taxes, every agency of government is called upon to justify its expenditures. If any expenditure cannot justify itself, it should be eliminated. Educational institutions and agencies may not escape such a test.*

So perfectly self-evident has it become that taxes are too high that, judging from continent-wide current expressions, there is virtually no dissent from it—certainly, there is no dissent by intelligent men and women. And we watch public opinion with vigilance.

The absurdity of what appears to be Mr. Jensen's thesis is the more apparent when we consider this: Some years ago, the efficiently conducted business concerns, railways, manufacturers and whatnot, found costs mounting too fast. They set about devising methods of introducing economies and closer efficiency. Vast savings were effected, and the economies achieved.

Now, were some one to have asserted that those business managers were antagonistic to business—were "attacking" business—he would simply have written himself down as illogical, ignorant and ill-advised.

That is what Mr. Jensen has apparently done. He himself knows that California Taxpayers' Association is not "attacking" California schools, that the Sonoma Report was not, and was never designed to be, an "attack on California schools." On the contrary, he himself knew already, that the purpose of the Survey and Report was to procure "Better Education for Sonoma County Youth at Less Costs," as the headline in the December, 1925, TAX DIGEST set forth. He knew that California Taxpayers' Association simply wishes to have introduced into the operation of the California schools some of the accepted and proven methods of saving and waste prevention which are at hand, to the end that there may be "*better education at less costs,*" not only for Sonoma County, but in every county.

If Mr. Jensen wrote this article, he is apparently asleep and would better wake up. The great movement for "*reasonable economy and efficiency in government,*" including school government, has gathered its tremendous force and had general acceptance, while he seems to have been hiding his head, ostrichlike, under the sand. Everyone else in the United States is well acquainted with it. We advise him to open his eyes and learn what is going on in the world.

We welcome constructive discussion, even adverse expressions. They are healthful. They compel care and conscientiousness. But if anyone, knowing, as that writer knows, that California Taxpayers' Association and the TAX DIGEST are *not* antagonistic to California schools; when he knows that on the contrary they are anxious for the highest good of the schools. and, then, writes such an article and the editor places over it that which appeared over the Jensen article, it is impossible to retain respect for such a writer, or believe in his sincerity.

A well known crude philosopher of the West once said: "I can take care of my enemies. It is my fool friends that worry me." Apropos, California schools should worry, when anyone, as did the writer in question, undertakes to "defend the schools" in any such manner, by sophism such as Socrates denominated "making the worse appear the better reason."

Co-operation instead of opposition would be much wiser, Mr. Jensen, and Mr. Chamberlain.

The Noble Vision of an American Banker

The Late Harry P. Davison and His Plans for Peacetime Red Cross Activities

By A FORMER RED CROSS WORKER

"Before the waters have subsided,
Or the embers have ceased to glow,
While the dead still lie unburied,
And the injured await relief,
——Comes the American Red Cross."

American Red Cross Building in Washington

Everyone remembers how, during the war, the people of the world depended on Government for so many things. It had been necessary apparently for Government temporarily to assume many functions which, by the American theory and practice, belong in the realm of private initiative, and private initiative appears to be a cardinal principle with THE TAX DIGEST. Therefore, I have volunteered this narrative, as an outstanding illustration—the great vision of the late Harry P. Davison, his plan for peacetime Red Cross work, and the present fruits from his sowing.

It was in 1919 that this matter first came to my attention. I was in United States army uniform as a militarized American Red Cross worker in France. Harry P. Davison was the head of the American Red Cross, and was in Paris. At the headquarters, one day, that year, I saw Mr. Davison hurrying through the lobby in that energetic way of his, his face aglow, obviously intent of purpose.

I knew him well enough to say, "Hello Mr. Davison; what's the hurry?"

"The Cannes Conference!" he exclaimed

And on he went, calling over his shoulder, "Lunch with me today—noon—Petite Palais."

During luncheon, Mr. Davison told me about it. I shall never forget. Here was an American banker—a member of the house of J. P. Morgan and Company of New York—concerned presumably with cold ledgers and credits and balances, and that sort of thing.

But he had gone upon a high mountain and there a vision had come to him—the vision by a man of large capacity, imbued with a humane purpose, and revealing statesmanlike understanding. However, let him tell it:

"One thing I have learned during this war and my connection with the Red Cross work. There is a danger that the peoples of the world will retain the habit of looking to Government for many functions which are not proper under our American theory of individual responsibility and initiative. It would overload Government, and atrophy the powers and capacities of the individual.

"The International Red Cross has been one of the world's finest institutions, and during wars has done great things for humanity. However, so soon as a war has ended, the Red Cross has lapsed into inactivity, awaiting another call for wartime service. It has been splendid, and the world owes it a large debt of gratitude and appreciation.

"I want you to consider this, however—such Red Cross activity confined to wartime is really negative. It takes care in part of the results of mankind's mistakes which have brought on the wars.

"Cannot we make of the Red Cross a constructive force? Cannot we make of it an agency to prevent wars, or tending towards that end?"

Mr. Davison paused. The glow of enthusiasm faded from his countenance. In its stead came a reflection of sadness, and then, as often the sky changes in its cloud effects, a look of horror came over him, and, shuddering, he interjected:

"This war! It has been more horrible than the world realizes. It has been ghastly, beyond comprehension. There have been magnificent sacrifices by fine, upstanding women and men and deeds of valor.

"But why not set at work these Red Cross ameliorating influences in peacetime as a means of war prevention, bringing the world peoples together in mutual understanding, mutual helpfulness? Why not set up a central international Red Cross clearing house, whither should flow, in peacetime, information relating to human ills and the means of curing them, and whence should go out, in peacetime, this information to the ends of the earth? Why not maintain at such headquarters men and women skilled in the treatment of great epidemics; for instance, typhus fever, and nation help nation to eradicate and prevent outbreaks of that scourge now so prevalent in half a dozen countries?

"Think of it! A great peacetime Red Cross performing such efficient international human service! Would it not be a powerful influence to prevent war?"

H. P. DAVISON

Mr. Davison had been "dabbing" at a French omelet, as we sat at table, and, in his fervor, had eaten little. He went on—

"Now—these Red Cross folks over here—I have not been able to make them see this thing as I see it. Up at Geneva, they insist that the Red Cross began as a wartime activity, has always been such, and, therefore, must always be such.

"So I conceived the idea of calling a conference of the Red Cross societies of the nations, the old International Red Cross to go on as it wills, and the others of us forming a new worldwide Association of Red Cross Societies, to inaugurate and carry on the peacetime work. And it is to be organized at a conference at Cannes (France). The work is to go on! I am sure it will be a great influence for peace, will help cure the habit of depending on Government for what should be done by private means, and, will, through the cooperation of the national societies, each contributing, bind the various peoples together in unity and constructive effort.

"Each cooperating national society will of course have the endorsement of its own government. That will be necessary in order that, when we work in a given country, we know we are personae gratae to the government there. But our funds will be derived from private sources, our workers will be non-governmental, and the friendship of man for man, regardless of boundary lines, will have full scope to produce its good results."

Mr. Davison in Washington, Later

We had come from France. One day, at Red Cross headquarters in Washington, I was climbing the central stairway, and met Mr. Davison, coming down, on the landing. I took the liberty of remarking that he appeared to be worn out, and needed a rest. He apparently remembered our luncheon in Paris, and his description that day of his Red Cross peacetime project, for he said:

"I am tired. You know how the Cannes Conference came out. It was not successful. My plan failed."

"Mr. Davison," I countered, "there is no such thing as failure when one does a kindly deed, or plans a kindly move, or even thinks a kindly thought. Such seed sown never dies. It is eternal. You and I might not live to see the full fruition of the sowing, but there will be fruition, and your idea will in time prevail."

"I wonder," he replied. "I wonder."

And he passed on downward. I never saw him again. Some months later, he fell ill at his Long Island home, fought with his accustomed tenacity against the malady, and, at last, died. I verily believe it was in part his feeling of partial failure as to the great Red Cross peacetime world association of national societies which weakened his resistance to the malady. Nevertheless, it was a wonderful conception, and promised much for mankind all over the world.

The Red Cross Today, and Mr. Davison's Vision Realized in Part

Now, what of it all? Was it failure? I assert, No! most emphatically, No! Take a rapid survey of the world, and the Red Cross, and human disaster since the war.

An earthquake in Japan, and resultant fires. A terrible thing. A whole world appalled, a nation fearfully stricken. So soon as authentic cable news came to American Red Cross headquarters in Washington, a cable credit for a million dollars went to Red Cross representatives in Tokio, for relief.

I have since talked with an Oriental consul-general in an important American city. In substance, he said:

"No one ever will be able to measure to what extent America hastening to Japan's relief has been an influence for preserving peace in the Pacific area. A fellow may be rather gruff one moment, even to the verge of offensiveness; but if, the next moment, he spring to an act of humanity, it is hard to quarrel with him."

A couple of billions have been poured into Europe and the Near East from the United States, given outright from private sources. Don't be impatient. Europe—part of it—seems to misunderstand America just now. But wait. In time matters will straighten out, and understanding take the place of misunderstanding, and Mr. Davison's idea will triumph.

It is based on the eternal truth that there is a common bond between the peoples, and that each individual should have a part in keeping that bond intact. By maintaining the great Red Cross institution, sustained by private contributions, captained and manned by private citizens, and operating independently of, but with the endorsement of, Government; by appealing to the universal sentiment of sympathy, and by sustaining it long enough, the world will come to understand, and peacetime cooperation of the many peoples, as Mr. Davison indicated, will work its inevitable and desirable ends.

Harry Davison was right! and he did not fail! Rather, he sowed seed which, in due time, will flower beautifully for humanity's good. Only, we need a little patience to await the time of fruition.

League of Nations Increases Expenses

In September, the League Assembly voted a budget of $4,749,563 for the current year expenses of the League of Nations, the International Labor Office and the World Court. This is a little larger than last year, but each state's contribution will be smaller, due to the fact that Germany now shares in the League's expenses.

Taxing Growing Timber as a Crop

Forestry Authorities Continue the Symposium on the Encouragement of Forestation and Reforestation

Prof. Fred R. Fairchild, Department of Economics, Yale University, who is chairman of the Forest Service Committee, United States Department of Agriculture. and Prof. Henry Schmitz, Department of Agriculture, University of Minnesota, continue this month in THE TAX DIGEST the symposium on the question of deferring taxation on growing trees until the timber has matured as a crop ready to be harvested.

The symposium began in the January TAX DIGEST, with Paper Number One by Prof. Woodbridge Metcalf, Extension Forester, University of California College of Agriculture, and United States Department of Agriculture Cooperator. Several papers remain to be printed in forthcoming issues of THE TAX DIGEST.

The subject was given added interest by the adoption at the November, 1926, election of an amendment to the California Constitution, which provides:

EXEMPTING FOREST TREES FROM TAXATION. Senate Constitutional Amendment 10. Amends Section 12¾ of Article XIII of Constitution. Exempts from taxation immature forest trees planted on lands not previously bearing merchantable timber, or planted or of natural growth, upon lands from which seventy per cent of merchantable original growth timber over sixteen inches in diameter has been removed; declares maturity of forest trees or timber shall be determined, after forty years from planting or removal of original timber, by a board comprising assessor of county wherein same are located and representatives from state boards of forestry and equalization.

Twenty years ago, the proposal was made that there be encouragement of timber growing by some such proviso as this. and it is only now receiving serious, detailed attention.

California Taxpayers' Association and the Tax Digest oppose exemption of property from taxation as a basic proposition. It is held, however, that this is not an exemption; rather, a treatment of timber as a crop, and the imposition of tax thereon, when the crop is mature.

Paper Number Two

FROM YALE UNIVERSITY

By PROF. FRED R. FAIRCHILD

Department of Economics, Yale University, New Haven, Conn.; and Chairman, Forest Service Inquiry Committee, Department of Agriculture

I have on numerous occasions put myself on record in favor of two principles which I regard as fundamental to the problem of forest taxation.

The first is the importance of giving to the law-making body the greatest possible degree of freedom with respect to taxation. In my opinion. the best constitution from the point of view of taxation is the one which is silent on that matter. As an example, I may refer to the State of Connecticut whose constitution nowhere mentions the word "taxation." As an example on the other side, all students of taxation have become familiar with the troubles which the State of Ohio suffers, under her rigid constitutional rule of uniformity in taxation. It appears to me that a state makes a serious error when it undertakes to limit by constitutional restrictions the freedom of its legislature to enact tax laws. After all, we must trust our law-making representatives, and it is very dangerous to undertake to bind the future on the basis of the knowledge and opinions of the present. Holding such views, I am naturally pleased to note that California has seen fit to remove some at least of those restrictions of her constitution which stood in the way of reform of her tax laws so far as they relate to growing trees.

My second principle is that income is a more appropriate basis than property in the taxation of forests. Upon this point I have expressed myself at considerable length elsewhere. I take it that whatever legislation follows the California amendment will be in the general direction of a substitution of income or yield taxation for the property tax, and such movement is, I believe, in the right direction.

At the present time, I am somewhat reluctant to express dogmatic opinions regarding the methods by which forests should be taxed. The Forest Taxation Inquiry, which is investigating the whole subject of the taxation of timber lands under my direction, will be engaged for the next five or six years at least in the assembling of facts regarding this subject.

Eventually, on the basis of such facts, it will doubtless arrive at conclusions which it is hoped will throw light upon the problem of the best methods for taxing timber lands. While I have as the result of my past studies arrived at certain conclusions, I am quite certain that the last word has not yet been said on this subject and am proceeding to the present investigation with an open mind, quite ready to accept the conclusions of this study, even though they should prove to be at variance with my present notions. I sincerely hope that a few years hence the findings of this Inquiry may put us all in better position to give advice on the subject of forest taxation.

Paper Number Three

FROM THE UNIVERSITY OF MINNESOTA

By PROF. HENRY SCHMITZ

Department of Agriculture, University of Minnesota, St. Paul

The question of forest taxation, since it must eventually be applied to approximately 500 million acres of land in the United States, is one of the biggest economic questions confronting our country. I believe also, since it is now known that agriculture cannot absorb this enormous acreage, or even a small part of it, in the near future, we are beginning to see more clearly that something must be done to keep these 500 million acres productive. Not even a country as rich as the United States can indefinitely carry such an enormous burden or overhead as is represented by 500 million acres of land.

Possibly you will not agree with me, that agriculture will not absorb even a small part of the area now classed as forest land. However, when one considers that it has taken American enterprise and ingenuity centuries to put 350 million acres, much of it prairie land, under the plow, and when one further considers the difficulty which agriculture finds itself in today, largely due to overproduction or under consumption, which in the last analysis amounts to the same thing, and that the area under cultivation is actually decreasing in many states, one cannot escape the conclusion that agriculture will not solve the land use problem in America. Furthermore, a prominent agricultural economist has recently predicted that before our agricultural revolution shall have subsided, approximately 40 per cent of the people now on farms will have moved to the city. This economist does not view this shift as a calamity, but rather as a mark of progress. In other words, he considers that about 15 per cent of our population engaged in agriculture on the area now devoted to agriculture will adequately meet the immediate agricultural needs of the nation.

Looking at this problem from a national point of view, then, we are confronted with two very important questions: first, the use of 500 million acres of land, and second, the employment of ten million people now engaged in agriculture.

If we recognize the fact that agriculture cannot use this large land area, that by far the largest part of it is devoid of any mineral or oil resources, only one productive use remains, and that is the growing of timber crops. The mere recognition of timber as a crop brings us face to face with the problem of giving this crop an equal break with agricultural crops. If it is proper to tax a forest crop 60 to 90 times during the period required for it to reach maturity, why not apply the same principle to all agricultural crops?

A Step in the Right Direction

Personally I am not at all certain that a change in the method of taxing forest crops will entirely solve the problem, but it is unquestionably a step in the right direction. The growing of forest crops must be financially profitable, before private capital will engage in the enterprise to any considerable extent. Without a doubt, one of the most potent reasons why timber cropping is not more profitable in many regions is because we are applying a system of taxation to a crop that was originally designed to apply to an actual resource. If the general property tax were properly applied, and the land owner would be given a reasonable assurance that it would be fairly applied until his crop reached maturity, there would be no need for special forest tax legislation. The fact that the general property tax has not been fairly applied to growing forests, is too obvious to require further elaboration.

In my opinion, it is economically unsound to exempt any property from its just burden of taxation, and one of the most serious errors made in connection with the consideration of forest taxation is the loose use of the word "exemption." Forest properties should, and I believe can, bear their just share of the tax burden. The question is one, then, of determining what this just share is. My own feeling is, that forest property should pay the regular land tax based each year on a nominal valuation of the land. The valuation placed on these lands should be such that the annual property tax would not be in excess of 5c or 10c per acre. At the time the crop is harvested, a certain percentage of the gross value should revert to the state, county and community in lieu of all back taxes. The exact percentage of the gross value so taken would and should vary in different regions, and should take into consideration the hazards connected with the growing of these crops and the rate of growth of trees in the particular region. In any event, it should not be too large.

It is perfectly obvious that in many counties a tax of 5c to 10c per acre on forest land will not be sufficient to meet the running expenses of the counties. It is likewise perfectly obvious that the counties are not showing much disposition to reduce their running expenses. In that event, it may be necessary for the state to assist the county in the way of subsidies, until the yield tax from mature timber comes in. This method of assisting the counties is anticipated by the law passed by the Michigan legislature several years ago.

In the long run, many states will have no choice whether they will or will not inaugurate a sound forest policy. Sheer economic necessity will drive them to it, and for this reason they may as well recognize the fact now, that the state will have to carry a part of the burden.

I have gone into this matter in considerable detail, in order that it may serve as a background to my answer to your question as to our attitude towards special forest tax legislation.

I am particularly impressed with that section of your law which deals with areas "from which 70 per cent of merchantable original growth has been removed." This will, in my opinion, permit of selective logging, which is going to be the salvation of many of our forest areas. You are to be congratulated on this section of your law. The title of your amendment, "Exempting forest trees from taxation," is a little misleading. Although it does exempt growing forests from taxation, I see no reason why the fact should be emphasized. Are not all other growing crops also exempt from taxation? To me this merely means that California has recognized trees as a crop, and as such it is entitled to the same consideration as other agricultural crops.

The people of Minnesota have just adopted by popular vote a somewhat similar constitutional amendment. This amendment reads as follows:

"Amendment to the Constitution of Minnesota by adding thereto a new article, to be appropriately numbered in the order of its adoption. Authorizing the enactment of laws encouraging and promoting forestation and reforestation of lands in this state, whether owned by private persons or the public, including provisions for definite and limited taxation of such lands during the term of years and for a yield tax at or after the end of such a term upon the timber and other forest products so grown."

It should be noted that this amendment is merely an enabling act. It does anticipate, however, a certain type of legislation which we believe is sound. This amendment has had the unanimous support of all foresters in Minnesota.

I have written at some length, because I feel that the question raised is of considerable importance, and is one which should receive a great amount of study.

The Fame of The Tax Digest Travels Far

At a Rotary Club dinner in San Diego recently, at which Mrs. Rose W. Hendee, Director of Field Service, California Taxpayers' Association, was the principal speaker, four visiting Rotarians were introduced, after the manner of Rotary Clubs the world over. When the first guest was presented to the diners, he remarked:

> I am from Montana. I am proud to remind you that recently THE TAX DIGEST contained an article by Governor Erickson of our state, in which he showed that Montana had been going out of debt at the rate of $100 a day. From what I have learned here, I am sure that California can do, proportionately to the volume of taxes, the same thing, if this economy and efficiency movement continue.

Another visiting Rotarian was from Oregon, and said:

> Montana 'has nothing on' Oregon. I call your attention to the fact that THE TAX DIGEST lately printed an article by C. C. Chapman of Portland, which, I understand, has been reprinted by several publications.

The third visiting Rotarian was from Idaho, and proudly pointed out:

> Please remember, while you are hearing of the representation of the several states in THE TAX DIGEST, that in the November number of that magazine there was an article by a distinguished Idahoan.—Lloyd A. Fenn, of Kooskia, a member of the Idaho Legislature.

Then arose a Rotarian from Oklahoma, and expressed this regret:

> My state has not been mentioned in THE TAX DIGEST for one matter which, I am sure, deserves countrywide notice—that the Oklahoma Taxpayers' Association has been the means of reducing taxes in my state by approximately 50 per cent.

A Tax on Noses

An exclusive dispatch from Lhasa, Tibet, in the Los Angeles Times recently told us:

> Snub-nosed Tibetan taxpayers are rejoicing over the latest edict of the autocratic and eccentric Dalai Lama. As a surtax to be utilized for the improvement of the Tibetan army the Dalai Lama has just ordered the tax collectors in his bizarre realm to levy a poll tax on every citizen, based on the size of the nose each possesses. Long Roman noses pay in some cases two or three times more than short retrousse noses.
>
> The Dalai Lama is a genius in this business of tangled taxation. Last year he invented an ear tax, making the Tibetans contribute to the state treasury according to the number of ears they possessed, gladdening the hearts of the taxpayers who had had an ear cut off, in some cases to enhance their beauty and others as punishment.

Use of Electricity Increases

The Interior Department reports an increase of more than 50 per cent in the use of electricity in the United States between 1921 and 1925. The increase was not confined to any particular section of the country.

Arizona State Taxes Decreased

By RUDOLPH KUCHLER

President, Arizona Taxpayers' Association

(Paper read at Western States Taxpayers' Conference in Los Angeles)

An increase of $2,529,562.91 was shown in the total amount of taxes levied for all purposes in Arizona for 1925 over the amount raised in 1924. This increase, which brought the 1925 total to $17,685,369, was due to an increase of more than $1,300,000 in state taxes, mainly on account of increased appropriations made by the last legislature for the educational institutions of the state. Special district taxation increased $628,874, and general county taxes $466,243, with city and town taxes increasing approximately $75,000.

RUDOLPH KUCHLER

It is gratifying to be able to report no such increase in the amount of taxes in 1926. The total raised by taxation during 1926 for state, county, special district and municipal purposes is $17,696,651, or an increase of $11,282 over the 1925 total. A comparison of the amounts raised for various purposes *shows a decrease in the amount raised for state purposes of $622,793.* This however, has been more than offset by the increase in the taxes to be raised for county purposes, amounting to $308,564, the increase in special district taxes amounting to $246,663, and in city taxes, amounting to $78,848. The 1926 figures present additional evidence of the tendency of local governmental costs to increase, while state and Federal taxes show slight reductions, and indicate the necessity for a campaign to enforce strict economy in the administration of local governmental units.

Bonded Indebtedness

Arizona has issued no new bonds since it was admitted to the Union in 1912. Every proposal that the limitation of bonded indebtedness fixed by the State Constitution be raised has been opposed by our Association. In spite of the fact that the bonded indebtedness of the state is only about three-quarters of a million dollars, the total bonded indebtedness of Arizona including all its political subdivisions was $47,544,589.13 at the close of 1925, an increase of $3,852,344 over the total of the previous year. Irrigation district and school district bonds were largely responsible for this increase.

By reason of the fact that a very large portion of the tax burden and of the increases in taxes caused by additional bond issues are for purely local purposes, where every item of expense is decided by the local community, it is becoming very apparent that the problem of reducing the aggregate tax burden of the state is one in which every local subdivision must do its full share in cutting down expenses.

Budget Review

An important feature of the work of the Taxpayers' Association of Arizona is its review of the proposed budget of each county and city. As these are the estimates upon which county, city and school district taxes are based, it is the policy of the Association to go over the list of estimated expenditures with the boards of supervisors of the various counties and the councils or commissions of the cities and towns, in an effort to discover and eliminate any of the proposed expenditures which may be found unnecessary. Public hearings provided for in the budget law give the Association an opportunity to appear and be of helpful service in this respect.

That work of budget review justifies the time and attention which the Association has given to it, is shown by the fact that reductions amounting to nearly half a million dollars were made in proposed county budgets for 1925, and proportionate reductions obtained in several city and town budgets.

Emergency Levies

Requests for authority to impose emergency levies were filed by several counties during the past year and were in each instance opposed by the Association. The largest of these was a request by Maricopa County for an emergency levy of over $80,000. All of these requests were denied.

State Legislature

A careful analysis of all measures affecting taxation is made by the auditing and legal department of the Association during each legislative session, when the Association opposes measures detrimental to the interests of the taxpayers of the state. Facts as to the effect of the various proposals are gathered by the Association and presented to the legislative committees whenever it becomes necessary for the Association to appear and explain its position relative to any proposed measure.

New Bond Issues

Numerous proposals to increase the bonded indebtedness of the state or some of its subdivisions were investigated by our Association. Those found to be unnecessary were opposed, and in the majority of cases were defeated, while others were reduced in amount.

During the past year there was a marked reduction in the amount of city and county bonds issued as compared with previous years, most of the new bond issues being for school districts or irrigation district purposes.

The Association vigorously opposed an initiated measure proposing to exempt automobiles from taxation, which would remove over $20,000,000 in taxable wealth from the tax rolls of the state. We also opposed a measure which if adopted would pave the way for adoption of an amendment to the Constitution to increase the limitation of the state bonded indebtedness by ten million dollars.

Taxpayers' Magazine

The Taxpayers' Magazine, published by the State Taxpayers' Association has been issued each month for thirteen years and has kept the public informed upon all matters of taxation. Many articles and tables printed in the magazine have been extensively copied by the press of the state. The information given in the magazine is accepted by all as authoritative, as it has always been the policy of the magazine to print nothing but accurate tax facts.

Co-operation with public officials in the solution of the perplexing problems of taxation, is the method employed by the Association, and this form of co-operation does not stop at state government, but extends through county, school district, and city to the smallest taxpaying unit in the state. Practically all the public officials welcome the assistance and co-operation of our Association.

An Eastern View of Our Election

This is from the Saturday Evening Post, and refers to California and the absurdly long list of propositions on which the voters were asked to express themselves in the November, 1926, election:

> In one state there were twenty-eight measures on the last ballot, and one of the large cities had eleven additional measures. Though a few were trivial or even ridiculous, most were of extraordinary fiscal complexity. The voters were asked to pass upon rival measures for highway taxation and finance which the most competent legislature, employing experts and holding extensive hearings, could not hope to pass upon intelligently without months of debate. Even the most public-spirited and well-informed voters reached a decision only after painstaking inquiry, while the mass of citizens, if they voted at all, must in the very nature of the case have been moved largely by such light or darkness as local and sectional prejudices threw upon the question.
>
> In general the voters were puzzled and benumbed by such an array of measures. One newspaper kept six men at work for months studying the question, and, of course, publishing the results. More than one educated and intelligent voter, unable to form so many opinions beforehand, took the newspaper to the polls and voted as therein instructed.

Those persons who are so eager to put before the voters their pet measures, if really and honestly desirous of promoting the public good would devote some of their efforts to securing the election of desirable and honest-minded legislators. It may be that if people cannot govern themselves through representatives, they cannot govern themselves at all.

Corporation Commissioner of California Authorizes Billion and a Half of Securities

By C. C. WAKEFIELD
Financial Editor, L. A. Express

During 1926 authority was given by the State Corporation Department for the sale of $1,554,440,163.29 par or face value of securities. This represents an increase of 846 per cent over the first year of "blue sky" enforcement in California—1915, when the total was only $183,631,895.

Forty-six of the 48 states have passed laws regulating the sale of securities. Many of the state laws radically differ in the methods pursued, but there has developed a close co-operation between the different states that is making it difficult for crooked promoters to repeat fraudulent financing.

Los Angeles City Committee Asks Personal Cooperation

By EDWIN BAKER

Secretary, Los Angeles City Committee, California Taxpayers' Association

The Los Angeles City Committee of the California Taxpayers' Association are now located in their new offices with the State Association at Suite 775, Subway Terminal Building, with entrances at 417 S. Hill St. and 420 S. Olive St., and cordially extend an invitation to all members to call and inspect the new quarters, meet the official personnel, inspect the work of each department, become thoroughly acquainted with the character and extent of our working program, and know the service we are rendering on behalf of the taxpayer. Unfortunately so few of our members maintain the close working relationship which should at all times prevail between the officials charged with the specific duties of carrying out the plans and purposes of an organization, and its membership.

While we are mutually interested as members in carrying forward the plans and purposes of the Association and are willing to co-operate with our time and energy in a program that has for its purpose economy and efficiency in governmental affairs, we are prone to leave the actual work to a chosen few such as the elective and appointive officials.

That situation would be indeed ideal whereby the rank and file of the membership could be aroused to the importance of the program as outlined by the Association and made to realize the wonderful service they could render by personal effort in carrying forward the message to their immediate friends and acquaintances and by keeping in intimate touch with the actual work as it progresses.

The Los Angeles Committee is striving to achieve that ideal and in that spirit solicits the co-operation of its membership and hereby conveys the assurance that all taxpayers will be cordially welcome at all times and every opportunity afforded them to counsel and advise with their officials on tax problems.

Penalties for Unpaid Assessments

The Committee is not unmindful of the penalties which many property owners have had to pay by reason of the collection by unscrupulous parties of unpaid assessments and are thoroughly in sympathy with any program that will afford them relief; but, owing to the fact that the fault lies with the present provisions of the various improvement acts, it will be necessary to change the present laws, and, with that object in view, certain recommendations will be made to the Legislature for the purpose of correcting the evils complained of and our legislative representative will be instructed either to urge the adoption of our recommendations, or to co-operate with others to seek to accomplish by appropriate legislation the same purpose.

For the fiscal year ended Sept. 30, 1926, government revenues in Haiti exceeded by 10 per cent those of 1924-25.

The following table has been prepared for the convenience of the taxpayers, bond and financial houses, banks and investors, so that they may have a table showing exactly how much it will cost for interest and redemption for each dollar of serial bonds issued. The amounts in the columns represent the total of interest and principal which must be repaid for each dollar borrowed on serial bonds for the different terms indicated in the column at the left, with interest at rates indicated at the head of the several columns. For example, for each dollar of five-year serial bonds at 4%, **$1.12** must be repaid in interest and principal. If they bear 5%, it will require **$1.15**; at 6%, **$1.18**, and at 7%, **$1.21**. Reference to the term of the bonds in the term column, and carried over to the specified interest rate which they bear, will at once show the total amount for any bonds commonly proposed.

For convenience in using this table, the points where interest and redemption amounts to approximately **$1.50**, **$2.00** and **$2.50** for each dollar borrowed on serial bonds, have been indicated by using bold face type. It will be noted that these several points are reached very much sooner on high than on low interest rates. There is a direct relationship between the interest rate, length of time for which bonds are issued, and the total to be paid for interest and redemption.

The Cost of the Seria

Amount Required for Interest and R

Terms

Term	4%	4¼%	4½%	4¾%	5%
5	1.12	1.1275	1.1350	1.1425	1.15
6	1.14	1.14875	1.1575	1.16625	1.1750
7	1.16	1.17	1.18	1.19	1.20
8	1.18	1.19125	1.2025	1.21375	1.2250
9	1.20	1.21250	1.2250	1.23750	1.25
10	1.22	1.23375	1.2475	1.26125	1.2750
11	1.24	1.2550	1.27	1.2850	1.30
12	1.26	1.27625	1.2925	1.30875	1.3250
13	1.28	1.29750	1.3150	1.33250	1.35
14	1.30	1.31875	1.3375	1.35625	1.3750
15	1.32	1.34	1.36	1.38	1.40
16	1.34	1.36125	1.3825	1.40375	1.4250
17	1.36	1.38250	1.4050	1.42750	1.45
18	1.38	1.40375	1.4275	1.45125	1.4750
19	1.40	1.4250	1.45	1.4750	**1.50**
20	1.42	1.44625	1.4725	1.49875	1.5250
21	1.44	1.46750	1.4950	**1.52250**	1.55
22	1.46	1.48875	**1.5175**	1.54625	1.5750
23	1.48	**1.51**	1.54	1.57	1.60
24	**1.50**	1.53125	1.5625	1.59375	1.6250
25	1.52	1.55250	1.5850	1.61750	1.65
26	1.54	1.57375	1.6075	1.64125	1.6750
27	1.56	1.5950	1.63	1.6650	1.70
28	1.58	1.61625	1.6525	1.68875	1.7250
29	1.60	1.63750	1.6750	1.71250	1.75
30	1.62	1.65875	1.6975	1.73625	1.7750
31	1.64	1.68	1.72	1.76	1.80
32	1.66	1.70125	1.7425	1.78375	1.8250
33	1.68	1.72250	1.7650	1.80750	1.85
34	1.70	1.74375	1.7875	1.83125	1.8750
35	1.72	1.7650	1.81	1.8550	1.90
36	1.74	1.78625	1.8325	1.87875	1.9250
37	1.76	1.80750	1.8550	1.90250	1.95
38	1.78	1.82875	1.8775	1.92625	1.9750
39	1.80	1.85	1.90	1.95	**2.00**
40	1.82	1.87125	1.9225	1.97375	2.0250
41	1.84	1.89250	1.9450	1.99750	2.05
42	1.86	1.91375	1.9675	**2.02125**	2.0750
43	1.88	1.9350	1.99	2.0450	2.10
44	1.90	1.95625	**2.0125**	2.06875	2.1250
45	1.92	1.97750	2.0350	2.09250	2.15
46	1.94	1.99875	2.0575	2.11625	2.1750
47	1.96	**2.02**	2.08	2.14	2.20
48	1.98	2.04125	2.1025	2.16375	2.2250
49	**2.00**	2.06250	2.1250	2.18750	2.25
50	2.02	2.08375	2.1475	2.21125	2.2750

The amounts in the columns represent total of interest at the left and interest rate at head of columns. To of bonds.

TAX-FREE SECUR

("Municipal" is here used in the larger legal districts.) The grand aggregate value of all mun increase of over 30 per cent over 1923, which t somewhat with ready sale of such securities, but 637,992—a new high record by a substantial mar

The 1925 figure was only slightly less than a billion dollars or over. Prior to 1919, there was totals were close to $500,000,000. The war period we have had a spree of municipal bonding—the 1922-23 the total dropped slightly, and in 1924-25 ated increase, especially so in California. Unless shrinkage is likely to occur in the immediate futu

ar *By Research Department,*
California Taxpayers' Association

ch Dollar of Serial Bonds at Various terest

5¾%	6%	6¼%	6½%	6¾%	7%
1.17250	1.18	1.18750	1.1950	1.20250	1.21
1.20125	1.21	1.21875	1.2275	1.23625	1.2450
1.23	1.24	1.25	1.26	1.27	1.28
1.25875	1.27	1.28125	1.2925	1.30375	1.3150
1.28750	1.30	1.31250	1.3250	1.33750	1.35
1.31625	1.33	1.34375	1.3575	1.37125	1.3850
1.3450	1.36	1.3750	1.39	1.4050	1.42
1.37375	1.39	1.40625	1.4225	1.43875	1.4550
1.40250	1.42	1.43750	1.4550	1.47250	1.49
1.43125	1.45	1.46875	1.4875	1.50625	1.5250
1.46	1.48	1.50	1.52	1.54	1.56
1.48875	1.51	1.53125	1.5525	1.57375	1.5950
1.51750	1.54	1.56250	1.5850	1.60750	1.63
1.54625	1.57	1.59375	1.6175	1.64125	1.6650
1.5750	1.60	1.6250	1.65	1.6750	1.70
1.60375	1.63	1.65625	1.6825	1.70875	1.7350
1.63250	1.66	1.68750	1.7150	1.74250	1.77
1.66125	1.69	1.71875	1.7475	1.77625	1.8050
1.69	1.72	1.75	1.78	1.81	1.84
1.71875	1.75	1.78725	1.8125	1.84375	1.8750
1.7475	1.78	1.81250	1.8450	1.87750	1.91
1.77625	1.81	1.84375	1.8775	1.91125	1.9450
1.8050	1.84	1.8750	1.91	1.9450	1.98
1.83375	1.87	1.90625	1.9425	1.97875	2.0150
1.86250	1.90	1.93750	1.9750	2.01250	2.05
1.89125	1.93	1.96875	2.0075	2.04625	2.0850
1.92	1.96	2.00	2.04	2.08	2.12
1.94875	1.99	2.03125	2.0725	2.11375	2.1550
1.97750	2.02	2.06250	2.1050	2.14750	2.19
2.00625	2.05	2.09375	2.1375	2.18125	2.2250
2.0350	2.08	2.1250	2.17	2.2150	2.26
2.06375	2.11	2.15625	2.2025	2.24875	2.2950
2.09250	2.14	2.1875	2.2350	2.28250	2.33
2.12125	2.17	2.21875	2.2675	2.31625	2.3650
2.15	2.20	2.25	2.30	2.35	2.40
2.17875	2.23	2.28125	2.3325	2.38375	2.4350
2.20750	2.26	2.31250	2.3650	2.41750	2.47
2.23625	2.29	2.34375	2.3975	2.45125	2.5050
2.2650	2.32	2.3750	2.43	2.4850	2.54
2.29375	2.35	2.40625	2.4625	2.51875	2.5750
2.32250	2.38	2.43750	2.4950	2.55250	2.61
2.35125	2.41	2.46875	2.5275	2.58625	2.6450
2.38	2.44	2.50	2.56	2.62	2.68
2.40875	2.47	2.53125	2.5925	2.65375	2.7150
2.43750	2.50	2.56250	2.6250	2.68750	2.75
2.46625	2.53	2.59375	2.6575	2.72125	2.7850

**st be repaid for each dollar borrowed for the term indicated
d, multiply amount of bonds by amount for term and interest**

THE UNITED STATES

the state, the county, the school and other special
d in the United States for 1924 was $1,398,953,158, an
The 1925 firmness in the money market interfered
ipal bonds disposed of ran over 1924, reaching $1,399,-

t was the fifth successive year in which the sales were
they ran over $500,000,000 and 1914-1917 the yearly
wn to a minimum. Thus it is evident that since 1919
ax-free securities. In 1921, the billion dollar era began,
ing up. The future gives promise of a greatly acceler-
where begin to realize where such procedure ends, no

This table shows how much the people must pay to retire any proposed bond issue. Likewise, the total amount of the lien which will be placed against their property by a bond issue for interest and principal may readily be ascertained.

These are the acid tests for every proposed expenditure of public money:

FIRST—Is the proposed plan a proper function of government?

SECOND—Can we afford it?

THIRD—Is the proposed plan the most economical possible to procure the needed results?

FOURTH—How can the money be raised equitably?

FIFTH—How may we secure the wisest and most economical expenditure of the money?

SIXTH—If this money is to be raised by bond issue, will the proposed improvement outlast the term of the bonds, or will we be paying on bonds when the improvement is entirely gone?

This last test frequently determines the limit of the term of the bonds, and, applying this to the table with interest rates obtainable, the total costs may be readily ascertained.

**THIS TABLE AS SEPARATE REPRINT
AVAILABLE TO ALL WHO ASK**

This table has been put on the press as a separate reprint from THE TAX DIGEST. Copies will be sent to all who write asking for them.

Saving School Money by Centralized Buying

Robert L. Bird, Superintendent of Schools, San Luis Obispo County, in response from an inquiry of the Research Department, California Taxpayers' Association, testifies that a substantial economy has been affected in San Luis Obispo County by centralized purchasing of school supplies. Supt. Bird's response follows:

By ROBERT L. BIRD

Superintendent of Schools, San Luis Obispo County

Your request for an account of our experience with county purchasing of school supplies came a few days ago. The only report that I have in writing or print is a talk that I gave at the last Superintendents' Convention. I am glad to enclose a copy of this if it will be of any service to you. We have demonstrated without any doubt that county purchasing pays the schools. However, it does add a great deal of clerical work and our last grand jury recognized this fact by recommending that we continue the service.

Statement by Supt. Bird at the County Superintendents' Convention, Lake Tahoe, Calif., October, 1926

The purchase of school supplies has always been a problem with rural school boards. San Luis Obispo County Boards made an attempt several years ago to form some sort of organization for co-operative purchasing of the ordinary school supplies. This was done with some degree of success for one year, but was discontinued because it was impossible to find someone who would be responsible for carrying out the necessary details. It had been the custom with certain supply houses to send their agents into the county, and it appeared that these agents were authorized to load up the schools with all kinds of supplies and charge whatever prices could be attached to the orders. We had instances where schools in the same neighborhood during the same trip of the agent were charged different prices. One country school was sent twelve quart bottles of red ink in a single order, or three gallons of red ink for a school of twenty-five pupils.

Some of the clerks had spoken to me after I became county superintendent relative to making another attempt at county purchasing. We saw that some effort should be made to protect the small schools against the over-ambitious agent. I took up the matter with the county purchasing agent here. During the year 1922-23 twenty-five schools accepted the plan.

The year previous, 1921-22, some of the prices paid for common articles were: Pens, per gross, $1.50; ink, per quart, $1.50; paste, per pint, $1; manila drawing paper, per ream, $3 25; legal cap, per ream, $5.40; blotters, per gross, $1; cut news, per pound, 19 cents. In addition the schools paid the freight. During the following year with only twenty-five schools represented, these prices were practically cut in two and prices paid for the same articles ranged as follows: Pens, 75 cents; ink, $1; paste, 65 cents; drawing paper, 90 cents; legal cap, $2.16; blotters, 35 cents; cut news, 5 cents.

Our plan proved a success from the first and in time all of the schools of the county adopted it. Last year our prices for the same articles were as follows: Pens, 50 cents; ink, 60 cents; paste, 45 cents; drawing paper, 63 cents; legal cap, $1.40; blotters, 27 cents; cut news, 4¾ cents. This year our prices are about the same, with possibly a little change higher or lower. During the year 1922-23 and subsequently, the prices are quoted delivered to San Luis Obispo or destination. The saving on freight alone is quite an item. The estimated saving to the schools on supplies purchased through the county purchasing agent is about $5000 per year. We have practically eliminated the visiting agent and time is saved to the teacher and school board.

During the first years of purchasing by this method, we received the orders from the various boards and gathered these under classifications for the purpose of receiving bids. After the bid was received, each order was sent to the successful bidder and was filled and sent directly to the school. This was not altogether successful, because a few schools ordered too much material and it was difficult to get a check on the materials and invoices. When there was a mistake it was hard to get an adjustment.

About this time our office was moved from the Court House to a vacant store room, and we decided to accumulate all of the orders and have the entire shipment sent to San Luis Obispo. This plan has proven very successful. Goods are sent here and checked, and the orders are made up for the individual schools to be taken by the teacher or clerk or by anyone who comes in from the district and is willing to take the package to the school. Our system of rural supervision has aided also in getting the packages to the rural schools. Now schools get what they want and do not need to take any more than is necessary. We are in a position to inspect the articles and make them right if there is any mistake in the shipment.

Our only regret in carrying out this plan is that the local dealers who were doing a legitimate business have been practically eliminated from participating in the business. But in so many cases the outside agents were reaping such an undeserved harvest, it appeared that something had to be done. Practically all of the local dealers throughout the county have stated that the plan should be continued.

Value and Character of the Public Domain

Secretary Hubert Work of the Interior Department, in a letter to Representative N. J. Sinnott of Oregon, chairman of the House Public Lands Committee, gives information which is of value in considering a proposal to give the states compensation for the presence therein of Federal lands which are exempt from taxation, or other state control. The subject was advanced in the public thought by the adoption of a resolution by the Western States Taxpayers' Conference held in Los Angeles during October, 1926, which resolution was:

> RESOLVED, that a committee of three be appointed to investigate and report on the advisability of urging the Federal Government to pay annually to states in which public lands are located, sums equivalent to the prevailing rate of taxes upon an equal acreage of similar lands in such states.

Also the National Tax Conference had the matter under consideration at Philadelphia in November, 1926. The TAX DIGEST takes from Secretary Work's letter the following statements:

> Ohio, Indiana, Illinois, Missouri, Alabama, Mississippi, Louisiana, Michigan, Arkansas, Florida, Iowa and Wisconsin were granted one section in each township, or one-thirty-sixth of the area of the township, for school purposes. California, Minnesota, Oregon, Kansas, Nebraska, Washington, Dakota, Montana, Idaho and Wyoming were granted two sections in each township, or one-eighteenth of the township, for school purposes. Utah, New Mexico, Arizona and Oklahoma were granted four sections in each township, or one-ninth of the total area of the land in the township.
>
> The total area granted Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, Washington, and Wyoming, of school sections in place aggregates a total of 49,276,303 acres, of which there remains unsurveyed an area of approximately 3,381,919 acres.
>
> One of my predecessors a few years ago made an estimate of the value of the "national estate" in the remaining public-land areas, substantially as follows:
>
> Sale value of the surface of public lands outside' national forests—190,000,000 acres—$310,000,000.
>
> Value of national forests and resources, $1,000,000,000.
>
> Royalty value of coal in public ownership; bituminous, 10,000,000,000 tons, at 10 cents; sub-bituminous, 30,000,000,000 tons at 8 cents, and lignite 50,000,000,000 tons, at 5 cents, aggregating $5,900,000,000.
>
> Royalty value of 700,000,000 barrels of oil, at 12½ per cent, $175,000,000.
>
> Royalty value of 50,000,000,000 barrels of shale oil, at 5 per cent, $5,000,000,000.
>
> Royalty value of 3,500,000,000 tons of phosphate, at 2 per cent, $280,000,000.
>
> Royalty value of 20,000,000 tons of potash, at 2 per cent, $30,000,000.
>
> Royalty value, Alaska; coal of all grades 20,000,000,000 tons, at 5 cents, $1,000,000,000 Twenty-five million barrels of oil, at 10 per cent $2,500,000.
>
> Total estimated royalty and sale value of public lands and resources, $13,697,500,000.
>
> In addition, he estimated the annual return from water power on the public lands, at 10 cents per horsepower per year, $1,550,000.

Secretary Work Opposes a Bill to Cede Unreserved Public Domain to the States

Secretary Work has also written Senator Robert N. Stanfield of Oregon, chairman, Committee on Public Lands and Surveys of the Senate, opposing "the enactment of a bill introduced in the Senate proposing that the Federal government cede the entire unreserved public domain to the states." Secretary Work took the position that, if such a bill were enacted, it "would mean the end of Federal reclamation and Federal conservation."

A Berlin cablegram says of the current German budget that "the only satisfaction the taxpayer finds in the bill presented to him today is the Presidential item. The total expenditures of President Von Hindenburg amount only to $149,000, in 1927, compared with $9,000,000 which Germany paid its princes before the war. President Von Hindenburg's pay envelope is $14,500; expenses and allowances, $134,500."

The profits of sales made by a foreign firm through any kind of an intermediary resident in New Zealand are taxable even though the contract is not concluded there. In other words, whenever a person resident in New Zealand is instrumental in securing an order for an American or any other foreign enterprise, the resulting profits will be assessable in the name of the agent, who shall have recourse against the seller for the amount of tax paid.

THE TAX DIGEST
JOHN LATHROP, Editor
Vol. 4 FEBRUARY, 1927 No. 2

Opinions expressed by writers herein are not necessarily the opinions of the Editor of this magazine, but are printed in the interests of free discussion.

A Final and Unbiased Study and Report To be Made on San Gabriel Flood Control

Three Eminent Engineers—Charles H. Paul, Frederick H. Fowler and Charles D. Marx—Employed by the Supervisors to Learn the Economic, Hydrographic, Engineering and Geologic Facts, and Suggest the Proper Procedure

Three eminent engineers, men of the ighest integrity and ability and adequate xperience are making a study and will eport on the San Gabriel flood control roblem. These engineers will go into he economic, hydrographic, geologic and ngineering facts. They were employed greeable with a suggestion made by a oint committee of several civic bodies, ransmitted through the chairman thereof, Arthur S. Bent, as president of the Los Angeles Chamber of Commerce, after the upervisors had asked the chamber to act. The supervisors accepted the suggestion, nd on January 10, 1927, the engineers egan their work. In order that the record may be complete, THE TAX DIGEST here rints the later history of this matter.

THE SUPERVISORS' REQUEST

On November 15, 1926, the Los Angeles Board of County Supervisors addressed a etter to the Los Angeles Chamber of Commerce, saying:

> We hereby request the Chamber of Commerce of Los Angeles, a body of public spirited citizens, o suggest and recommend to this Board some lan for an unprejudiced and unbiased investigation of the whole San Gabriel project, to the nd that public confidence in this great undertaking may not be misplaced.

The Chamber of Commerce directors on November 23, 1926, advised the supervisors:

> The Board of Directors of the Los Angeles Chamber of Commerce appointed a special committee to consider this matter. This committee deemed it of public interest to call into co-operation representatives of other civic bodies, to-wit: he Los Angeles Clearing House, the Los Angeles Section of the American Society of Civil Engineers, the Municipal League and California Taxpayers' Association.

The committee of the Chamber of Commerce consisted of Arthur S. Bent, president of the chamber, chairman; Geo. I. Cochran, Harry J. Bauer, William Lacy and John W. Kemp. The Clearing House was represented by W. R. Morehouse; the Los Angeles Section, American Society of Civil Engineers, by H. A. Van Norman, president, and Raymond A. Hill, past-president; the Municipal League by H. L. Moller, president, and Clark E. Bell, member of the executive committee; California Taxpayers' Association by Joy A. Winans, chairman of the Los Angeles City Committee, and John Lathrop, editor, THE TAX DIGEST.

This committee met several times, and on December 21, 1926, Mr. Bent, the chairman, sent to the Board of Supervisors a letter outlining a suggested plan of procedure and the employment of three engineers, Charles H. Paul of Dayton, O.; Frederick H. Fowler of San Francisco, and Charles D. Marx of Stanford University, with instructions to study and report on the control and conservation of the flood waters of the San Gabriel, balancing all hydrographic and economic factors.

On December 27, the Board of Supervisors officially accepted the proposal in the form of a resolution which employed the engineers in the manner suggested. On January 10, the engineers arrived in Los Angeles and were given a suite of two rooms at the Los Angeles Chamber of Commerce, with equipment adequate to their needs. They proceeded immediately with their duties, it being understood that they would be able to report by the end of March.

The action of the Chamber of Commerce and the Joint Committee and the Supervisors has apparently been endorsed by the public, which seems to rejoice that at last a competent, adequate, unbiased and final study and report will be made which will settle, it is hoped for all time, the controversy which has unfortunately been waged over flood control action in Los Angeles County.

The three engineers are men of the highest ability and experience, none of whom has ever expressed an opinion so far as is known on flood control matters in Los Angeles County, and who have had to do with none of the previous reports. *They entered upon their work absolutely without any thesis to prove or disprove; were given an open commission and instructed to learn the facts—hydrographic, economic, engineering and geologic.*

THE TAX DIGEST here prints in full the letter of the Los Angeles Chamber of Commerce to the supervisors, and the resolution of the supervisors accepting the proposals. The taxpayers are urged to read these two communications with exceeding care, in order to get the complete facts upon which to base their judgment.

THE CHAMBER OF COMMERCE PROPOSAL

The Los Angeles Chamber of Commerce.

Office of the President.
December 21, 1926.

Honorable Board of Supervisors,
Hall of Records,
Los Angeles.

Gentlemen:

The Los Angeles Chamber of Commerce and the other organizations it has associated with itself in connection with the San Gabriel Dam question, which you referred to us, fully appreciating the honor and responsibility, suggest the following plan of procedure which we hope will clarify the situation and expedite the construction of necessary flood control works on the San Gabriel. In order that our conclusions may be clearly understood, we beg to review the matter briefly as follows:

On November 15th we received an invitation from you to make certain suggestions in accordance with the formal resolution passed by your Honorable Body on November 10th, reading: "We hereby request the Chamber of Commerce of Los Angeles, a body of public spirited citizens, to suggest and recommend to this Board some plan for an unprejudiced and unbiased investigation of the whole San Gabriel project, to the end that public confidence in this great undertaking may not be misplaced."

The matter was placed before the Board of Directors of this Chamber at its first meeting following the receipt of your communication, and on November 23rd, we wrote you in part as follows: "The Board of Directors of the Los Angeles Chamber of Commerce appointed a special committee to consider this matter. This committee deemed it of public interest to call int co-operation representatives of other civic bodies to-wit: the Los Angeles Clearing House, the Lo Angeles Section of the American Society of Civi Engineers, the Municipal League and the California Taxpayers' Association.

The various organizations were represented b the following personnel:

Los Angeles Chamber of Commerce—Arthur S Bent, chairman; George I. Cochran, Harry J Bauer, William Lacy, John W. Kemp.

The Los Angeles Clearing House—W. R. Morehouse.

Los Angeles Section, American Society of Civi Engineers—H. A. Van Norman, president; Raymond A. Hill, past-president.

Municipal League—H. L. Moller, president Clark E. Bell, member executive committee.

California Taxpayers' Association—Joy A Winans, chairman, Los Angeles Committee; Joh Lathrop, editor, The Tax Digest.

By unanimous vote, this combined group recommend to your Honorable Body the following procedure:

We will suggest to you the names of thre representative engineers whose standing shoul establish confidence in the public mind, you t appoint these men as an investigating body t be instructed by you in an open letter to mak a thorough study of all phases of the control an conservation of the flood waters of the Sa Gabriel, and to make a public report of thei findings.

Also that all engineering and other data bearin upon this project, in possession of your Honorable Body, or the Engineering Department o the Los Angeles County Flood Control Distric be placed at the disposal of these engineers t facilitate their study.

On November 24th, we received a letter fro you indicating your approval of this general pla of procedure, and immediately proceeded to th selection of engineers for this important tas The Chamber of Commerce committee, with th sincere and earnest co-operation of the othe civic bodies above named, determined upon basis of selection, after long discussion of th importance of the various factors to be considere

Since the investigating board is to be composed of technical men, the Los Angeles Sectio American Society of Civil Engineers, was aske by the others of this group to rate a numbe of the best qualified engineers according to thei professional standing, technical training, exper ence with this type of problem, soundness of jud ment, and their freedom from technical or pe sonal bias.

After very thorough investigation and conside ation of the qualifications of over fifty engineer including all names which had been suggeste to us, the Los Angeles Section, American Societ of Civil Engineers, submitted a final list of fiftee names to our group, together with their rating o each point tabulated in the selection schedule.

This difficult and delicate task was performe in a spirit of high public service, and so conf dent were the representatives of the Chamber o Commerce and the other civic bodies of th scientific fairness of this selection, that our choic r the board of engineers was made from the rst few names on this list.

In order that there might be nothing to detract om public confidence in the report of this board f engineers, it was unanimously agreed among s that, irrespective of technical qualifications, no ian should be selected who had had contact with ie controversy, or who was in any way assoiated with any of the parties thereto.

We then took the liberty of ascertaining the vailability of these engineers for immediate serve in order that there might be no delay.

We now beg to recommend to your Honorable ody the appointment of Charles H. Paul, Fredrick H. Fowler, and Charles D. Marx as a Board f Engineers, and further recommend that they e instructed as follows:

> 'Make a complete investigation and study of all phases of the control and conservation of the flood waters of the San Gabriel and make a public report of your findings and conclusions as to that plan of development which best balances all hydraulic and economic factors."

The professional records of these engineers are iven herewith for your information and conderation:

HARLES H. PAUL—Born 1875 at Rockport, Mass.; educated at Massachusetts Institute of Technology; from 1896 to 1904 on the water supply of various eastern cities; from 1904 to 1915 with the United States Reclamation Service, during which time he was in charge of the design and construction of the Arrowrock Dam; since 1915 has been chief engineer and consulting engineer of Miami Conservancy District, and in private practice as a consulting engineer; member and director, American Society of Civil Engineers. Present address, Dayton Trust & Savings Bldg., Dayton, Ohio.

REDERICK H. FOWLER—Born 1879 at Custer, Montana; graduated 1905 from Stanford University; from 1905 to 1910 on general engineering work, principally in California; from 1910 to 1922 with United States Forest Service, first as hydro-electric engineer and later as engineering representative of the Federal Power Commission in California and Western Nevada; since 1922 in private practice as a consulting engineer; member American Society of Civil Engineers. Present address, 1300 First National Bank Bldg., San Francisco.

HARLES D. MARX—Born 1857 at Toledo, Ohio; holds engineering degrees from several American and European universities; prior to 1891 principally on railroad and public works; since 1891 professor of civil engineering at Stanford University, and engaged in practice as a consulting engineer; member and past-president, American Society of Civil Engineers and chairman, Arch Dam Test Committee for Engineering Foundation. Present address, Stanford University, California.

We believe that the Board of Engineers should stablish an office in Los Angeles, where all data ill be readily available, in order that the investiation may be expedited without sacrificing thoroughness. It is believed by our committee that the investigation and study can be completed in about sixty working days and that a report can be submitted by the end of March.

We take the liberty of further suggesting that the compensation of the Board of Engineers be fixed at a total sum of from $25,000 to $30,000.

This total fee, plus allowances for unavoidable delays, should cover all costs of the office of the board, the staffs of the three engineers engaged upon the work, and all traveling expenses incurred in connection therewith. It is understood that the Los Angeles County Flood Control District will conduct such surveys and field investigations as may be found necessary by the Board of Engineers.

We thank you for the confidence you have reposed in us, and trust that the sincere efforts of this group of civic bodies will meet with your approval.

Respectfully yours,

LOS ANGELES CHAMBER OF COMMERCE.

(Signed) ARTHUR S. BENT,
President.

THE SUPERVISORS ACCEPT PLAN

Office of the Board of Supervisors of the County of Los Angeles, State of California, Monday, December 27, 1926, 8:30 a. m.

The Board of Supervisors of Los Angeles County Flood Control District met pursuant to adjournment. Present: Supervisors R. F. McClellan, chairman, presiding; Fred T. Beaty, J. H. Bean, Sidney T. Graves and Henry W. Wright; and L. E. Lampton, clerk, by Mame B. Beatty, deputy clerk.

In re flood control: Order approving recommendations of Los Angeles Chamber of Commerce and other organizations relating to plan of procedure for proposed settlement of controversy relating to San Gabriel Dam project, and appointing Board of Engineers for investigation and report.

A report by the Los Angeles Chamber of Commerce, signed by Arthur S. Bent, president, dated December 21, 1926, suggesting, in behalf of said Chamber of Commerce and other organizations named in said report with which it is associated in connection with investigation of the San Gabriel Dam project, a plan of procedure for clarifying said situation and expediting construction of necessary flood control work on the San Gabriel, is presented; and, on motion of Supervisor Graves, duly seconded and carried, it is ordered that said plan of procedure and recommendations contained in said report, be, and they are hereby approved by this board, and that Charles H. Paul, Frederick H. Fowler and Charles D. Marx, be, and they are hereby appointed as a Board of Consulting Engineers, at salaries of $100.00 per day each, plus expenses, for a period not exceeding sixty days, to make a complete investigation and study of all phases of the flood control projects for the control and conservation of the waters of the San Gabriel River and make a report of their findings and conclusions to this board.

How Taxes Enter Into the Family Budget

Mrs. Charles H. Richmond, former president of the Hollywood Woman's Club, spent last summer in Europe, and was in many countries, including Switzerland, where she attended the sessions of the League of Nations. Mrs. Richmond was asked to write her reactions on taxes and the family budget, in the light of her observations abroad and the comparisons naturally made upon her return to the United States, because of the contrasts.

It is significant that, although she found here our strong tide of prosperity, she nevertheless urges caution in public expenditures, and counsels the housewife to remember that taxes, taxes, taxes enter into every item of the budget of the family.

By WILLA S. (MRS. CHARLES H.) RICHMOND
Past President, Hollywood Woman's Club

In the price of every article which is bought for household use, there is the factor of taxes, and taxes enter into the cost of housing, especially rentals. This is a truth which has not yet entered adequately into the consciousness of the women of the land, or of the men, either, for that matter, as they consider the family budget.

I shall not here dwell at great length on the advisability of budgeting the family revenue. I shall assume it as desirable—as long since having passed into our economy as an accepted practice. The same facts argue for family budgeting as argue for governmental budgeting, and I am justified in assuming that all intelligent persons accept government budgeting as not only advisable, but as demanded, in the interest of the taxpayer and of government itself.

It is merely reasonable foresight and prudence to budget ahead. To survey the prospective available resources and needs, and capacities to pay, within normal limits of economy and frugality, is common sense and a basis for comfort and happiness.

Many families have learned to budget, and practice it more or less faithfully, although more should—and, indeed, all should, rich and poor, especially those of moderate income. Budgeting tends toward thrift, stabilizes the business of the government and the family, and helps to make the economic life secure. However, in considering family budgeting, it will be well to give more careful heed to the factor of taxes which the family pays. Let us illustrate:

The housewife on the first of the month sends her rent check, which amount includes interest on the value of the property, insurance, repairs, depreciation, and taxes which the owner has paid.

The housewife goes to market, and, as she fills her basket, she is helping to pay taxes paid by the market master, taxes paid by the transport agency, and taxes paid by the farmer or truck gardener who produces the food.

When the Housewife Pays and Buys

The housewife goes shopping to buy the clothing for the family, and, as she pays for it, she pays the taxes of the merchant, taxes of the transport company that hauls the goods, and taxes of the wholesale house or factory which sold the goods to the merchant; above all, taxes on the location, furnishings and decorations of the shop.

The housewife takes the family to the theatre, and, as she busy her tickets, she is paying her share of the taxes imposed upon the theatre owner.

And so on throughout the list of the family expenditures, including even the life insurance policies, the premiums on which contains the factor of taxes paid by the company.

And so the process of paying taxes is absolutely constant throughout the household year. It has become apparent lately that this factor of taxes has grown too rapidly, and has become burdensome.

I understand the Research Department of California Taxpayers' Association computes that about one-sixth of the income of the people of California goes to pay Federal, state and local taxes. Or, in other words, that if a man work six days, he works one of those days for the government.

I believe firmly in the American spirit of progress. I should not be content to advocate or accept any sociologic dictum which would place in the pathway of progress an insurmountable obstacle. It is true, nevertheless, that we need to exercise caution lest our collective, community desires run away with our capacities to pay. And it is, therefore, a healthy sign that as a community we are intensely studying these taxation problems, first to get the facts, and then to interpret these facts in the light of twentieth century life.

MRS. CHAS. H. RICHMOND

It was my pleasure during the past year to spend some months in Europe, and, upon my return, I was much impressed with the larger life and greater opportunities which the average family is accorded in this country as compared with Europe, and the emancipation of women in the United States, not alone in regard to their participation in public life, but in emancipation from drudgery.

This does not justify us, however, in throwing caution to the winds; indeed, the stronger sweep of the tide of prosperity should make us the more cautious, inasmuch as it is a well known law of human nature that there is a certain element of danger even in prosperity itself.

A large per cent of income of every kind is spent by women. All industrial and business structures, factories and skyscrapers are built and operated to maintain homes. Seventy per cent of our laws relate directly or indirectly to the home and the protection of the woman and child. No individual should study taxation and its use more than the housewife. All protection, all education, and all comforts in the home relate to this. *Therefore, she of all citizens should protect herself, her home and her children by a knowledge of this subject, and a demand that we do not pay more taxes than the conduct of government requires and that what is paid be used for the advancement of that rock and foundation of government, the American home.*

Mexico's Highway Program

A Federal highway program was inaugurated in Mexico in Sept. 1925, with funds provided by tobacco taxes and by a special tax of 3 centavos per liter (about 6 cents per gallon) on first-hand sales of gasoline. This program called for three main highways radiating from Mexico City —one to the Texas frontier at Neuvo Laredo (756 miles), another to the Pacific Ocean at Acapulco (275 miles), and a third to Puebla (80 miles)—besides a road extending from the Mexican terminus of the International Railways at Arriago to Comitan on the Guatemalan border.

Spain Has an Economy Program

The Spanish government has announced that on February 12, 1927, short-time obligations amounting to 1,095,000,000 pesetas will have to be met. Announcement was also made that during the three preceding months, treasury payments had been made to the amount of 853,000,000 pesetas as against 905,000,000 pesetas during the same period of last year, a reduction of 52,000,000 pesetas. The Government announces its intention to continue to adhere to the program of economy which it has followed the past three years. (A peseta is about 20 cents in American money.)

Better Financing of Public Improvements

Proposed State Legislation for Relief of Property Owners in Various Assessment Districts

The Los Angeles City Committee, California Taxpayers' Association, has worked out a State legislative proposal to provide a better method of financing public improvements, giving relief from "loan sharks." The proposal takes the form of resolutions adopted by the City Committee, submitted to the Board of Directors, California Taxpayers' Association, at San Francisco Jan. 14, 1926. The resolutions were referred to the tax counselor, M. D. Lack, with instructions to have introduced in the State Legislature the necessary bill for an act, and then submit it by referendum to the Directors for final action.

WHEREAS, street improvements in Los Angeles are financed by formation of special assessment districts under various State Acts. These State Acts are of two main types regarding the nature of the method of collection of the assessment. The first and most commonly used is the Act of 1911, under which the assessment lies as an individual assessment of a specific amount against each individual piece of property. The second is the Acts of 1915 and 1925, under which the lien is against all the property in the district and is not a specific lien against each individual piece of property. Under the second type, the collection is made in the same manner as the regular tax bill and the annual payments are in reality a part of the regular tax bill. The first type of assessment and the securities issued thereon are subject to several serious objections, as follows:

1. The nature of the security, being a lien of comparatively small amount against each individual piece of property, yet with a possibility existing that the lien may exceed the actual value thereof, and entailing as it does minute attention and detail as to collection and foreclosure in case of default is not a security which appeals to large investors and does not, therefore, command low rates of interest.

2. The passing of small liens of this character into the hands of irresponsible investors has led to much abuse and hardship, particularly on questions of notice fees and penalties.

3. The assessments being separate, precludes a reliable and dependable system of notices and bills. The farthest possible to go in the matter of notices has been to have a stamp put on the tax bill stating that there is an assessment, but it is obviously impossible to state the amount thereof. In many cases these assessments are levied between the presentation of the annual tax bills and hence the stamp on the tax bill comes too late.

4. Assessments smaller than twenty-five dollars do not go to bond but must be paid in cash and become due and payable on very short notice, and, if not so paid, penalties are added and they are subject to immediate suit of foreclosure and attorney fees attached.

5. The assessment is levied on a front foot basis without reference to the depth or value of the property resulting in injustice and in some cases actual confiscation of property.

The second type of bonds is not subject to any of these defects, but under them it is not possible to pay off the assessment against any piece of property. The fact that it cannot be paid is one of the factors which make such bonds preferable to investors, thus securing a low rate of interest which acts automatically to reduce the desirability of paying off the claim.

The second type of bonds first came into use in unincorporated territory of the counties, where streets were being improved through territory where but a small percentage of the lots were occupied by residences.

The Act of 1915 provided that the assessor should levy the tax on the taxable property in the district. This resulted in such a divergence from the system of front foot assessment, that, after one or two proceedings had been carried through, no more districts could be formed under the Act because the people residing in the district were not willing to vote to assess themselves two or three times as much for improving in front of their lots as would be the non-resident owner of the vacant lots alongside.

The attempt to use the 1915 Act in the case of Holly Street in Pasadena brought out the fact that a certain merchant whose store was within the proposed district would have been compelled to pay assessments of $19,000 on his stock of goods. Of course, he would not have paid, but would have moved out of that district.

The Act of 1925 corrects that error by making the assessment on the basis of the land value only. The 1925 Act introduces another innovation in that it allows protest on the basis of area of property owned. Under the 1915 Act the voters as such control. The whole theory of these Acts is that the improvement to be made is to be for the benefit of the property in the district and that the property shall pay in proportion to the benefit. Giving power to a voter not a property owner to have a say as to whether the improvement shall be undertaken or not, is not in conformity with the theory of these Acts. The 1915 Act does not provide for zones of benefit, but the Act of 1925 does.

It would seem that a protest should have weight in proportion to the probable amount to be paid in assessments. In other words, property in the zone of full benefit should have protest weight to the full of its assessed land value; in a zone of 50% benefit, protest weight of one-half of the assessed value.

Either of these Acts gives the legislative body power to override all protests by a four-fifths vote. A better provision would be that, if a protest contained less than 60 per cent of the maximum protest weight possible in the district, then it could be overridden by a four-fifths vote of the members of the legislative body. If it contained less than 40%, it could be denied by a majority vote.

The 1925 Act fails to provide any means by which bonds may be sold for the construction work, so that the contractor may be paid progress payments in cash.

Now, THEREFORE, be it resolved that the Board of Directors of California Taxpayers' Association be requested to favor before the State Legislature the adoption either of amendments to the Acquisition and Improvement Act of 1925, or of a new Act modeled thereon which would effect the following changes:

1. Give protests in zone of full benefit weight in proportion to the assessed land value as shown by the assessor's records.
2. Give protests in other zones such proportion of such weight as the percentage of benefit shall bear to that in the zone of full benefit.
3. If a protest contains over 60% of the maximum protest weight possible in the district, it shall be final.
4. If a protest contains 40% but not 60% of said protest weight, the legislative body may deny the protest by a four-fifths vote.
5. If the protest contains less than 40%, the protest may be denied by a majority vote.
6. Provide for issuance and sale of bonds to cover 75% of the estimated cost of the construction and 100% of estimated incidental expenses before the letting of the contract and the payment to the contractor in cash as the work progresses, of amounts not exceeding 75% of the work completed.
7. Provide that, after completion and final acceptance, sufficient bonds shall be issued and sold to complete the payment and take care of any error in the estimate of expenditures..
8. The use of an Act of the character of either the 1915 or 1925 Acts entails a large amount of clerical overhead in the offices of the Auditor and Tax Collector in annually billing and collecting the assessments. Some provision should be made for the collection of a suitable amount to reimburse the County or Municipality for such outlay.

A Bill For a County Budgeting Act

Annual budgetting by California counties would be provided for by the enactment of a bill which was introduced in the State Senate by Senator F. S. Boggs of Stockton. It was drafted by M. D. Lack, Tax Counselor of California Taxpayers' Association, and endorsed by the Board of Directors of the Association. The text of the original draft follows:

A changed psychology and changed conditions with relation to functions proper for government, prevailing in present times, as compared to that existing in the past, has brought about a demand for wider and more expensive governmental service, and the support of many departures in government, not known or contemplated in previous years, with a consequent large increase in the amount and importance of government business, financial as well as otherwise, and this increasing importance and volume demands the adoption of the best and most modern, sound, business practices. The placing of the determination of County revenues and expenditures upon a uniform budgetary basis, such as has been found necessary, and has been unanimously adopted by practically all success private businesses, seems to be one of these most insistent and reasonable demands.

The proposed uniform budget law contained in the following pages has been drawn with that thought in mind. At least two other primary fundamentals have been carefully considered and protected in its construction.

1. The preservation of the authority and means of the Boards of Supervisors and other officials to administer the affairs of their Counties with the least possible restrictions, commensurate with successful procedure.

2. The providing of uniform machinery for the determination of public expenditures so simplified as to be readily understandable by, and because of its uniformity, familiar to the taxpayer. His thorough understanding of the proposed expenditures of his County will serve two major purposes:

   (a) It will apprise him of their necessity and make him much more sympathetic with them, and consequently remove much of the discontent that grows out of misconception.

   (b) It will enable him to take part in the consideration of appropriations for expenditures for support of the County government and to offer information and suggestion thereon, before such appropriations are finally determined. Such suggestion and information will undoubtedly prove of value in many cases. Under the provisions of the proposed Act, he is permitted to sit in at the budget hearings and inquire into the necessity and advisability of any proposed appropriation and offer the value of his suggestion and information thereon.

The proposal contains no provision permitting outside interference with the County's affairs, in fact, no appeal is provided from the decision of the Board of Supervisors as to what the final appropriation shall be. After having the benefit of all the information that may be presented with reference to appropriations, its decision, as to the proper amount thereof, is final.

The carrying out of the proposals embodied will entail very little additional work on the part of any official, as practically all of the information contemplated therein is now necessary in the determination of tax levies.

The Act has been drawn with the aid of County officials and others familiar with governmental procedure, and embodies, uniformly, their best thought and suggestion. Their assistance and cooperation is gratefully acknowledged.

An act to amend section three thousand seven hundred fourteen of the Political Code of the State of California relating to the levy of taxes.

The people of the State of California do enact as follows:

SECTION 1. Section three thousand seven hundred fourteen of the Political Code is hereby amended to read as follows:

3714. On or before the first day of June in each year, each County Official, elective or appointive, in charge of an office, department, service or institution of the County, shall file with the County Auditor of such County, a detailed and itemized estimate, showing both the probable revenues from sources other than taxation that will accrue to his department, office or institution during the ensuing fiscal year, and all expenditures required by such department, office or institution for the same period. The County Board of Supervisors shall submit to the County Auditor a detailed statement showing all new road and bridge construction to be financed from the County Road and Bridge fund, each Road District fund, the Permanent Highway fund, the State Gasoline Tax Highway fund, and from bond issues theretofore issued, if any, for the then current fiscal year, together with the cost thereof as computed by the County Engineer or any special engineer that may have been put in charge thereof. It shall be the duty of such engineer to prepare such estimates of cost for the Board of Supervisors of the County. The Board shall also submit a similar statement showing their road and bridge maintenance or betterment program, as nearly as can be estimated, as well as a detailed estimate of all expenditures for construction or improvement purposes proposed to be made from the proceeds of bond or warrants or other income not yet authorized.

The estimates required in this Section shall be submitted on forms prescribed by the State Board of Equalization, and provided by the County Auditor of each County, and may only be varied or departed from with the approval of said Board. The Auditor is hereby directed to provide such forms, and it is made his duty to prepare the estimates for interest and debt redemption requirements and any other estimates, the preparation of which properly falls within the duties of his office.

Each official failing or refusing to file the estimates herein provided, shall forfeit the sum of ten dollars ($10.00) per day for each day of delay; provided, that the total penalty against any one official shall not exceed one hundred dollars ($100.00) in any one year, and provided further, that in the absence or disability of any such official, such estimates shall be furnished by the official or employee in charge of such office, department, service or institution, during his absence or disability.

2. From such estimates, the County Auditor shall prepare a tabulation showing the complete expenditure program of the County for the ensuing fiscal year, and the sources of revenue by which it is to be financed. Such tabulation shall set forth the estimated receipts from sources other than taxation for each office, department, service or institution, for the ensuing fiscal year, the actual receipts for the preceding fiscal year, estimated receipts for the current fiscal year, the estimated surplus or unencumbered treasury balances at the close of the then current fiscal year, and the amount proposed to be raised by taxation; the estimated expenditures for each office, department, service or institution for the ensuing fiscal year, the actual expenditures for the last completed fiscal year, the estimated expenditures for the current fiscal year, all existing contracts or other obligations, if any, that will affect ensuing year revenues, and the sum necessary to be provided as a "reserve fund" as hereinafter provided.

Such estimates, appropriations, and expenditures, shall be classified under the general classes of (1) Salaries and Wages; (2) Maintenance and Support; (3) Capital Outlay; (4) Interest and Debt Redemption; and, (5) Expenditures proposed to be made from bond or warrant or other income not yet authorized.

Within the general class of "Salaries and Wages", each salary shall be set forth separately, together with the title or designation of the recipient. Wages for day labor may be given in totals by designating the general purpose or object for which the expenditure is to be made. Expenditures coming under the general classification of "Maintenance and Support" shall show the major subdivisions for which such expenditure is to be employed. Expenditures for "Capital Outlay" shall set forth the object of each expenditure, separately. Under the general class of "Interest and Debt Redemption" shall be set forth separately each series or issue of bonds and warrants, together with its individual requirement for interest and redemption. The total amount of emergency warrants issued during the preceding fiscal year shall be set forth separately, together with a statement showing the amount issued for each emergency.

3. The said tabulation shall be submitted by the Auditor to the Clerk of the Board of Supervisors on or before the twentieth day of June of each year. Said Board shall, immediately upon receipt thereof, consider the same in detail, and shall on or before the fifteenth day of July, make any revisions, reductions or additions therein that it may deem advisable; and shall correct estimated surpluses to agree with actual unencumbered surplus remaining in each fund on the first Monday in July, provided, however, that the estimate submitted by any official as designated herein shall not be increased or reduced until such official shall have first had a hearing thereon before said Board. The Board of Supervisors may add to such tabulation, if it deem advisable, an appropriation to be known as an unbudgeted reserve which shall not exceed in the aggregate ten per cent of the total amount of said budget, and which shall be available for appropriation by a four-fifths vote of said Board, to cover unforseen requirements as they may arise. Said budget shall contain an item to be known as the "general reserve fund", which shall be carried over to the next ensuing fiscal year to meet the cash requirements of all funds to which the County's credit may be legally extended for that portion of such fiscal year prior to the receipt of taxes therein. Sums withdrawn from such "general reserve fund" shall be returned thereto out of the respective appropriations in favor of which it was so withdrawn, and sixty per cent of the amount thereof shall, at the end of the fiscal year to which it was carried over, revert to the County general fund. Said tabulation with such revisions, additions, or changes as have been made therein, as herein provided, shall constitute the preliminary County budget for the fiscal year, which it is intended to cover. Said budget shall, beginning on or before the twentieth day of July, be printed in full, in pamphlet form in quantities sufficient to supply one copy to each taxpayer requesting same, and said Board of Supervisors shall cause to be published, once each week for two successive weeks, in a newspaper of general circulation throughout the County, notice that said budget has been prepared and is available for distribution to taxpayers desiring a copy thereof, which notice shall also set forth that on a date named therein, which date shall be not later than the tenth day of August thereafter, the County Board of Supervisors will meet for the purpose of fixing the final budget and determining tax levies, designating the time and place of such meeting, and setting forth that any taxpayer may appear thereat and be heard for or against any part of said budget.

4. On or before the tenth day of August of each year, the County Board of Supervisors shall meet at the time and place designated in the notice, provided in section three hereof, at which time and place any taxpayer may appear and be heard for or against any part of such budget. Such hearing may be continued from day to day until concluded, but not to exceed a total of ten days. The Board of Supervisors shall have power to call in the officials in charge of any office, department, service or institution, at the time the estimates for their respective offices are under consideration, for examination concerning such estimates, and such official shall be called by said Board upon the request of any taxpayer for questioning, either by the taxpayer or by the Board, upon such estimates.

Upon the conclusion of such hearing, the County Board of Supervisors shall fix and determine each item of the budget separately, and shall, by resolution, adopt the budget as so finally determined, and enter the same in detail, in the official minutes of the Board, and shall then proceed to fix the rate of County taxes, designating the number of cents levied for each fund upon each one hundred dollars of assessed value of the County, to raise the amount of the estimated expenditures as finally determined, less the total of the estimated revenues from sources other than taxation, including available surplus, and such expenditures as are to be made from bond or warrant sources, and must levy the State and County taxes. All taxes shall be levied, upon the taxable property in the County, as provided by law, in specific sums, and the tax for County and local purposes shall not exceed the amount specified in the budget, after allowing 5% for delinquency, as provided by Section 3696 of this Code, provided that it shall not be lawful for any Board of Supervisors of any County in the State to levy, nor shall any tax greater than fifty cents (50c) on each hundred dollars ($100.00) of property be levied and collected in any one year, to pay the bonded indebtedness or judgment arising therefrom, of this State, or of any County or Municipality in this State.

The Clerk of the Board of Supervisors shall immediately forward a copy of the completed budget and tax levies to both the State Board of Equalization and the State Controller.

5. The estimates of expenditures, itemized and classified, as required in Section 2 hereof, and as finally fixed and adopted in detail by said Board of Supervisors, shall constitute the appropriations for the County for the fiscal year, intended to be covered thereby, and the County Supervisors and every other County official shall be limited in the making of expenditures or the incurring of liabilities to the amount of such detailed appropriations and classifications, respectively; provided, that upon a resolution, formally adopted by the County Board of Supervisors at a regular or special meeting, and entered upon its minutes, transfers, or revisions within the general class of "Salaries and Wages" and of "Maintenance and Support" may be made. Transfers between the general classes provided in Section 2 hereof shall not be permitted, provided that in the case of road and bridge maintenance appropriations, any lawful transfer, deemed necessary, may be made. Where any budget shall contain an expenditure program to be financed from a bond issue to be authorized thereafter, no such expenditure shall be made or obligations therefor incurred, until such bonds have been duly authorized and sold. Expenditures made, liabilities incurred, or warrants issued, in excess of any of the detailed budget appropriations as originally determined, or as thereafter revised by transfer, as herein provided, shall not be a liability of the County, but the official making or incurring such expenditure, or issuing such warrant shall be liable therefor personally, and upon his official bond. The County Board of Supervisors shall approve no claim, and the County Auditor shall issue no warrant for any expenditure in excess of said detailed budget appropriation, as finally adopted by said Board of Supervisors, or as revised under the provisions herein, except upon an order of a Court of competent jurisdiction, or for an emergency, as hereinafter provided.

6. In a public emergency, other than such as are specifically hereinafter described, and which could not reasonably have been foreseen at the time of making the budget, requiring the expenditure of money not provided for in the budget, the County Board of Supervisors, by unanimous vote of the members present at any meeting, the time and place of which all members shall have had reasonable notice, shall adopt and enter upon its minutes a resolution, stating the facts constituting the emergency and the estimated amount of money required to meet the emergency, and shall publish the same, together with a notice that a public hearing thereon will be held at the time and place designated therein, which shall be not less than one week after the date of said publication, at which any taxpayer may appear and be heard for or against the expenditure of money for such alleged emergency. Such resolution and notice shall be published once in a County newspaper of general circulation, or, if there be no such newspaper of general circulation, then by posting notice thereof, prominently, in each Supervisorial District in the County. Upon the conclusion of such hearing, if the County Board of Supervisors deem it advisable, they may proceed to make the expenditures necessary to met the said emergency and no more, provided that upon the happening of any emergency caused by fire, flood, explosion, storm, earthquake, epidemic, riot or insurrection, or for the immediate preservation of order or of public health, or for the restoration to a condition of usefulness of any public property, the usefulness of which has been destroyed by accident, or for the relief of a stricken community, overtaken by calamity, or for the settlement of approved claims for personal injuries, or property damages, exclusive of claims arising from the operation of any public utilities, owned by the County, or to meet mandatory expenditures required by law, the Board of Supervisors may upon the adoption by the unanimous vote of the members present at any meeting, the time and place of which all of the members of such Board shall have had reasonable notice, of a resolution stating the facts constituting the emergency and entering the same upon the minutes, make the expenditure necessary to meet such emergency, without further notice or hearing.

All emergency expenditures shall be paid for by the issuance of emergency warrants, which shall be paid from any monies on hand in the County treasury, in the fund properly chargeable with such expenditure, and the County Treasurer is hereby authorized and directed to pay such warrants out of any monies in the treasury in such fund. If, at any time, there shall be insufficient monies on hand in the treasury to pay any of such warrants, then such warrants shall be registered, bear interest and be called in the manner provided by law for other County warrants. The County Auditor shall include in the annual tabulation of expenditures to be submitted to the Board of Supervisors the total amount of emergency warrants issued during the preceding fiscal year, and said Board shall include in its tax levies a levy sufficient to raise an amount equal to the total of such warrants, provided that the County Supervisors, if they deem it advisable, instead of including the amount of such emergency warrants in their budget levy, may fund the same, or any part thereof, into bonds, in the manner provided by law.

The unencumbered balance remaining in any fund or appropriation at the end of the fiscal year shall be carried over to the credit of such fund or appropriation or department for the next fiscal year, and shall be deducted from amount finally determined as necessary to be expended by that fund, appropriation or department for such fiscal year, provided that all balances remaining to the credit of any appropriation, department or fund which is not to be continued in the succeeding fiscal year shall revert to the general fund except as to such funds as belong to special districts and are not a part of general County finances.

7. On or before the first business day of each month the County Auditor shall submit to the County Board of Supervisors a statement showing the condition of each separate budget appropriation, the original amount thereof and the balance remaining in such appropriation.

8. It is hereby made the duty of the State Board of Equalization to prescribe forms to initiate or approve changes therein whenever in its judgment same are advisable, and to promulgate such rules, regulations and classifications as may be necessary to carry out the provisions of this Act.

9. Any person violating any of the provisions of this Act, or refusing or neglecting to comply therewith, shall be guilty of a misdemeanor.

10. All Acts or parts of Acts in conflict with this Act are hereby repealed.

National Manufacturer's Association Gives Tax Facts to National Grange

By JAMES EMERY

Counsel, National Association of Manufacturers, to National Grange Convention in Portland, Me.

The farmers and business men of the United States are confronted with a staggering burden of local taxation, administered too frequently under an unsound system which makes it easy to get into debt, difficult to control expenditure, and is inequitably distributing the burdens over the property within the States.

The first fact with which we are confronted is that all the gains made in the Federal field, either in the reduction of the national debt or annual Federal expenditure, are more than equalized by the rising expenditure of the States and their subdivisions and the enormous increase in their permanent debt. On June 30, 1919, the Federal or national debt at its peak stood at $25,482,000,000. By August 30, 1925, this had been reduced to $19,381,000,000. In 1913, the bonded debt of our States and their communities amounted to $3,188,697,000. In 1925, this debt amounted to $10,261,854,000. During the last three years, 1922 to 1925, the local debt increased at the rate of $1,000,000,000 a year. Nor is that all. State and local governments are issuing tax-exempt securities at the rate of $1,300,000,000 a year.

The broad picture we have, then, is that in 1924 the total expenditure for government, national, state and local, was approximately $10,252,000,000. It was more in 1925: it will be still more in 1926, although in each year Federal expenditure was less. Of the great total above, the Federal Government is spending annually a little over $3,000,000,000, and state and local government over $7,250,000,000.

Now, taxation is indispensable to government, and government is indispensable to individual and collective security. It is not the fact of taxation, but its amount and form, which threaten to make it oppressive and injurious. The major part of all these sums for Federal taxes is raised in the larger volume by individual and corporate income taxation; but the chief source of State and local revenue is real property, real estate and its improvements in the city, the farm and its improvements in the country.

What do these vast figures mean in terms of production and saving and self-denial of the individual who must carry the burden? It means the expenditure for and by the American Government annually of a sum equal to half our savings banks deposits. It means a sum greater than the value of the crops raised on 6,500,000 American farms using 340,000,000 acres of land. It means that our annual wheat crop, the largest in the world, if turned over to our State Governments, would just about meet their expenditures for 1925. It means that while we are the largest producers of foodstuffs and cotton in the world, the value of both crops, if turned over to the local subdivisions of the States. cities, towns, counties and townships, would not meet their revenue requirements for last year. We lead all nations in industrial production, but the net income of all the manufacturing corporations of the United States is not equal to the combined expenditure of State and local government. Neither would all the money in circulation in the United States pay their bills for last year.

Mayor J. L. Davie of Oakland Makes a Remarkable Statement on Taxes

By JOHN L. DAVIE
Mayor, Oakland, California, in the Oakland Times

Oakland's exorbitant tax rate of $6.10 (on each $100 of assessed valuation) is absolutely prohibitive of solid industrial growth. It repulses industries desiring to locate here just as it frightens the man who would like to own his own home. I have said this in previous articles to the press, I repeat it because it can not be too strongly emphasized. *For big industry, Oakland has superlative advantages in land, transportation facilities and climate. With a $3 tax rate, national concerns would fight for our factory sites. They would spend millions constructing manufacturing plants. They would add millions to Oakland's annual payroll. With their development would grow the industrial prosperity of every man and woman in this city.*

(Advocating consolidation of the city and county of Oakland.) With such consolidation, Oakland's tax rate could be cut in half. The big industries would flood in, the individual taxpayer would not be afraid of having his home taxed away from him, and Oakland's future would no longer be a thing of doubt. My opinions are based on 25 years of actual experience in public life. In my first administration I ran the city on a city tax rate of $1, paid all obligations and had no deficit.

Organize, Citizens, Or Your Tax Burdens Will Grow Heavier

Editorial in the OAKLAND TIMES

Many improvements must be made, if this community is to advance. With the cost of local government growing at an alarming pace and with bond interest mounting annually, how are you going to meet the bills? Will you remain apathetic until taxation has reached the stage of confiscation?

Santa Barbara County's Promising Work

By FRED D. FENN
Director of Circulation

Our work in the field in Santa Barbara County has brought to light the keen interest in our work taken by the people here. On every hand we have had the most cordial reception. This is a community of real workers and they seem to have the faculty of finishing what they start. This applies to the entire county and to every group with which we have had contact. There is every indication that a survey will be asked for here immediately following the close of the first campaign for membership and subscriptions.

Members of the City Planning Commission, Santa Barbara City, which has been very active of late, are interested in our movement. The newspapers have been cordial, and we are under obligation to both of them for many courtesies and vigorous articles.

Mrs. Hendee's public addresses have been well received and she has been welcomed before many representative organizations. These observations apply both to the northern and southern sections of the county.

One can not resist the temptation to refer also to the physical and scenic beauties of this county, and to the charms of the cities and the countryside. Thousands of automobilists have seen these things. To all others who tour California highways I say—see Santa Barbara County! Explore her highways and byways, and thus become acquainted with a community than which there is none more beautiful or attractive under the high sun of heaven! Meet the Santa Barbara people, and you will return home prouder of that part of the Golden State than you have been in the past.

American Private Loans Abroad

By ROBERT W. DUNN

Author, American Foreign Investments

American private interests have loaned to foreign governments, provinces, and municipalities approximately $4,000,000,000. These loans carry an interest rate averaging from 6½ to 7 per cent, and their purposes are ostensibly for government railroad construction, public works, highways, national banks, sanitation projects, purchase of government equipment, port improvements, exchange stabilization, and general floating indebtedness.

Between $800,000,000 and $900,000,000 of this investment in government loans is in Canada, over $325,000,000 in France, nearly $300,000,000 in British bonds, over $200,000,000 in Argentina, and so on in the following order: Belgium, Germany, Japan, Brazil, Dutch East Indies, Russia, Norway, Denmark, Australia, Netherlands, Cuba, Switzerland, Mexico, Philippines, Sweden, Poland, Chile, etc. About $850,000,000 is invested in bonds of Latin American republics and $1,500,000 in European countries, and half a billion in Asia and the Orient.

Investments in loans floated by foreign corporations and by American corporations with major investments abroad, in addition to so-called direct investments by Americans abroad, are now estimated at over $7,000,000,000. Most of this investment —about $5,000,000,000 of it—is, of course, in Canada and in Latin America, but it has been growing significantly in Europe during the last two years. Direct investments in Asia are still comparatively negligible.

Taking the two kinds of investments together—the government loans and the corporate and direct investments—we find that out of every $100 invested abroad by Americans about $70 goes to Canada and Latin-American countries; the bulk of the remainder to Europe.

Restraint, or Liberty Under the Law

By C. E. WANTLAND

(In Los Angeles Realtor)

One of the most prominent leaders of the state's industries was quoted recently as follows:

"In national political life we have destroyed party responsibility and substituted a bloc system that is almost daily seeking to trade us out of our liberties. As one lone illustration: There are on the Federal statute books 5000 laws with penalties governing railroads. On the statute books of the states there are 200,000 other railroad laws, regulating and controlling railroad management.

"A common line of restraint runs through all of them. It is in the direction of standardizing conduct and management. Standardized management is put above initiative and originality. Restraint is preferred to liberty under law.

"We should be profoundly concerned with this state of affairs. It is to me a terrifying thing that great business leaders must say that the prosperity of the American people depends upon what Congress does. There is a profound relation between government and social and economic progress; no one need deny or question the fact, but if we keep our government geared to American institutions, we need not suffer the terror that chills us when our legislators meet.

"In this great state of ours (California) one must go in some way before twelve different commissions, boards and officers fully to organize an irrigation district. Bureaucracy and bloc legislation menace our free institutions.

"The summons is clear and loud that we concern ourselves with the sort of government we have and whither it drifts."

Some plan may be urged to limit the number of constitutional amendments proposed at each session by the legislature and by initiative petition. In Oregon only nineteen initiative measures were voted on at the last election, but there is an agitation now under way to limit in some way initiative activities. A recent editorial in the Portland Oregonian included this:

"The common method of getting measures on the ballot is to employ petition circulators, who are paid five cents or ten cents per name. The signers are in large part voters, who do not care whether the measure is submitted or not. They sign because they are pestered to do so."

Counsels Study of School Costs

"On the face of it, there has been a rather astonishing increase in the cost of schools. The expenditures of public grammar and high schools in the Unittd States are seven times as much as they were in 1900, according to the National Industrial Conference Board, while the population has increased by only one-half. Many will say that this demonstrates that the schools of the United States could do their work on less money. * * * The people demand more and better school work than they had 25 years ago, and they must expect to pay much more for it. However, the expenditures should be analyzed in the most careful way, to see if any of them could be made more moderate."—*Watsonville Pajaronian.*

REVIEWS OF BOOKS

BERKELEY SCHOOL PROPERTIES SURVEY, Berkeley, by Jesse B. Sears, Ph. D., Professor of Education, Stanford University, and Director of the Survey Commission.

A most comprehensive and penetrating report is "The Berkeley School Properties Survey" made last summer by Dr. Sears and his colleagues on the Survey Commission. The problem has been approached in the same businesslike way that a railway would reorganize its system or a great corporation plan its future expansion and finance.

Dr. Sears' Commission first studied Berkeley's present housing facilities, stating the problem of the survey, the educational needs of the city, the present program, the adequacy of the present school plant, the estimated expansion of building needs and Berkeley's ability to finance schools. Then when the present status of the schools is clear to the reader, Part II outlines the proposed building program and proposes a carefully worked out plan for financing the whole project. The bond issue called for would bring the schools up to a high point of efficiency and take care of calculated expansion for seven years. The plan has been so worked out that after that time the city could proceed henceforth on a pay-as-you-go plan.

The report is replete with relevant statistics, graphs and maps. Apparently, no consideration vital to a satisfactory solution of the problem has been overlooked. Berkeley's present facilities, present and future needs and ability to meet these needs are as scientifically appraised as any board of directors could ask in planning the future growth of a great industry. There is no guess work in the findings. Conclusions have been arrived at after measuring the factors with the most objective yard-sticks available.

The whole survey is shot through with the idea of getting the most for the money expended. Economy of budgeting capital outlays is stressed so that the most necessary expenditures be made first. The pressure of the tax burden is never lost sight of. The report points out in many places that great savings will be effected if the projected expenditures are made now while conditions are favorable, instead of allowing a policy of procrastination to complicate the problem so that much greater expenditures will ultimately be

The integration of present facilities, present and future needs and ability to pay into one sound scheme is a forward-looking step in sane governmental procedure. Dr. Sears has caught admirably the trend toward efficiency and economy in governmental affairs. It is a consummation devoutly to be hoped for that such "educational engineering" will bear fruit in "putting more sense in the California tax dollar!"

N. B. T.

STATE INCOME TAXATION, by Edie, Lionel D., Bureau of Business Research, Indiana University, Bloomington, Ind.

In the preface to this booklet, the author states: "Although this study has been undertaken with the intention of presenting an impartial and factual analysis, nevertheless, wherever fairly decisive conclusions have been warranted, there has been no hesitation to state the results of the analysis in positive and definite form. This treatment is in no sense a plea for or against the income tax, but is intended to supply authentic information and interpretation to those responsible for shaping the revenue systems of the states."

The pamphlet contains a fund of information on the income tax, showing the extent of state income taxes, the revenue produced thereby, the cost of administering this tax, the redistribution, the effect on property taxes and the effect on the cost of government, who pays the tax and the effect on business. A number of tables and charts are used to make the subject more easily comprehensible.

D. B.

A MODEL REGISTRATION SYSTEM—National Municipal League, 261 Broadway, New York.

"There are three outstanding criteria by which any registration system may be appraised: namely, first, convenience to the voted; second, cost of operation; and, third, effectiveness in preventing fraudulent voting." This introduces the report of the committee on election administration of the National Municipal League, which proposes a Model Registration System. Inasmuch as the re-writing of California's registration law has been broached, students thereof may find valu

ELEMENTARY PRINCIPLES OF ECONOMICS, by Richard T. Ely, Ph.D., LL.D., and George Ray Wicker, Macmillan Company, New York.

This is the fourth edition of a text book which has attained high standing and popularity in the schools of this and foreign countries. It outlines the theory of economics which today is most generally accepted by economists, and does not present or discuss conflicting views. The subject is so comprehensively but simply treated that the casual reader as well as the student will obtain from it a very clear idea of the principles of economics.

The book outlines briefly economic history, showing the early stages of industrial development—the pastoral, the agricultural and the handicraft stages—from man's primitive struggle for food and shelter down to the present-day complicated social and industrial machinery which provides necessities and undreamed of luxuries. Utilities and goods are well defined—the law of diminishing utility, and economic order of consumption.

Factors of production—land, labor and capital—their interdependence that the final result may be achieved; the organization of production—the advantages and disadvantages of large scale production, the relation of society to trusts, private and public ownership, are all thoroughly explained. Values, monopolies, credit and banking are touched upon briefly.

Distribution, the labor problem, interest, profits—the part managing ability plays in their determination—socialism—public finance—Federal expenditures from 1791 to date, classification of public revenues, direct and indirect taxes, tariff for revenue or protection, and a balanced revenue system are analyzed.

Dr. Ely is an acknowledged authority on economics, and he has treated the subject in an interesting as well as instructive way. Students will find it of great value and much may be gained from it in even a cursory reading.

D. B.

THE FLORIDA ESTATES CASE DECISION

State of Florida v. Andrew W. Mellon, as Secretary of the Treasury of the United States, and David H. Blair, as Commissioner of Internal Revenue of the United States; Supreme Court of the United States.

The constitutionality of the Federal estate tax law was sustained in the original suit. Justice Sutherland declares that "the act is a law of the United States made in pursuance of the Constitution, and, therefore, the supreme law of the land, the constitution or laws of the States to the contrary notwithstanding. Whenever the constitutional powers of the Federal Government and those of the State come into conflict, the latter must yield." Ex parte Virginia, 100 U. S. 339, 346; Brown v. Walker, 161 U. S. 591, 606; Cummings v. Chicago, 188 U. S. 410, 429; Lane County v. Oregon 7 Wall, 71, 77."

An analysis of the decision was given as follows by Ralph W. Smith, counselor in inheritance and estate tax law, Los Angeles, at the request of THE TAX DIGEST:

"Congress in the adoption of its 1926 Federal Estate (Inheritance Tax) Act granted to the taxpayer a credit up to 80 per cent of the amount of the Federal estate tax for inheritance taxes paid under State laws. Formerly the credit was but 25 per cent, and was increased to 80 per cent as a retaliatory, or, better, a coercive measure, against such States as Florida, Alabama and Nevada, which do not collect revenue by means of death taxes, hoping thereby to swing these States into line for the sake of uniformity and thus obliterate them as 'isles of safety' for those citizens who sought to minimize the death charges on their estates by change of residence.

"The legitimacy of the purpose of the Federal government was challenged by the State of Florida in the United States Supreme Court, which Court on January 3, 1927, upheld the credit feature of the law. Although the sole right or privilege of transmitting property at death is conferred by the sovereign state and not by the Federal government, we find, in the opinion of Mr. Justice Sutherland, a death knell to those who would champion state rights, in language more far reaching from a Federal standpoint than that ever used by that greatest of all centralists or federalists, Chief Justice John Marshall, who a century and a half ago presided over our highest Court and so ably announced in his decision the supremacy of the national government as against the dominance of the state. We find in this recent opinion the Court using this language,

> 'Whenever the constitutional powers of the Federal government and those of the state come into conflict, the latter must yield.'

"It is certain that Congress has no constitutional or other right to control the devolution of property. This right belongs to the State. It is therefore difficult for one to determine any encroachment of the State upon the Federal powers, since the rights involved are all State given rights. The decision also lays down the rule that Congress cannot accommodate its legislation to the conflicting or dissimilar laws of the several States nor control the diverse conditions to be found in the laws of the various States. This is axiomatic, yet by the decision Congress can, by means of the allowance of a credit in its revenue law, force any legitimate form of tax upon the State. The decision thus settles for all times a vexing problem while its far reaching effect is apparent. . . .

"This court decision would seem in a measure to validate the right of the Federal government to remain in the death duty field. If so, credence is given to the field of thought of the group who advocate the abolition of all State inheritance taxes and the collection of all death taxes by the Federal government and the apportioning of such collections to the various States."

Econ

FOREST YIELD TAXES

The Present Situation
and
Trends in Taxing Growing Forests

NATURAL RESOURCES PRODUCTION DEPARTMENT
Chamber of Commerce of the United States
Washington, D. C.

FOREWORD

The problem of removing some of the tax inequalities under which our growing forests labor and at the same time providing sufficient revenue to maintain local governments is receiving much attention.

Referenda ordered by four state legislatures to decide whether the constitutions shall be amended; special measures pending in eight states; discussion and agitation in fifteen other states, is the record of the interest throughout the country in this subject according to a recent preliminary survey by the Natural Resources Production Department.

The importance of this question of taxation was recognized by the Chamber of Commerce of the United States in its referendum on a National Forestry Policy in 1923, which approved the principle that the nation should ultimately rely mainly on private enterprise to produce its future timber supply and pointed out that unsound taxation was one of the important obstacles to such private undertakings.

According to principles approved in the referendum, taxation of growing timber should be based upon the principle of the yield tax with reasonable uniformity among the states. "Yield tax" is considered to be the general term covering the principle of collecting the tax on a forest when it is harvested, as distinguished from the ordinary system of property taxation which levies a tax each year on the value of both lands and forest growth regardless of whether or not they yield income.

Realizing that no one forest tax system will meet the varying conditions in different sections of the country the Chamber is committed only to the broad principle and urges no specific plan. The purpose of this bulletin is to present to our members a brief picture of the present situation and of the action taken in various states, with the hope that it will explain this much-talked-about "forest yield tax" and stimulate constructive thought on a subject becoming increasingly prominent.

Those who wish additional data on the subject are referred to the compilation of "State Forest Tax Laws," issued by the National Lumber Manufacturers Association, and to a bulletin on "Forest Property Taxation" which the United States Forest Service plans to issue.

NATURAL RESOURCES PRODUCTION
DEPARTMENT,
W. DuB. Brookings, *Manager.*
F. Winslow, *Assistant Manager.*

October 6, 1926.

FOREST TAXATION

The Forest Industry

Close to the front among the industries on which our national welfare and prosperity are based stands "forest products." This industry with its various branches engaged in production, harvesting and fabrication, spreads over 38 states and provides employment for half a million wage earners.

Its annual production of lumber is valued at one and a half billion dollars, while naval stores, pulpwood and other products add many millions to the total.

Supplying the raw material to maintain this industry has made such demands on our reserves that recent estimates indicate that seventy per cent of the original forests are gone, and that present forest growth is only one-fourth of the annual cut.

The absence of forestry policies to encourage the replacing of old crops with new has resulted in the virtual abandonment of large areas of forest land. At present there are over eighty million acres of cut-over land, without seed trees, not producing, and classed as waste lands. There are over one hundred and thirty-five million acres of inferior second-growth timber which is not considered merchantable.

If an adequate supply of domestic timber is to be developed for future needs it is essential that these areas be brought back into production.

Position of the Chamber

The Chamber of Commerce of the United States has called attention to the situation. In its Referendum No. 42, it pointed out the duty of the federal government and the states in cooperatively reforesting these waste areas and in protecting forests from fire. It also indicated the possibilities for individual enterprise in growing crops of trees—"commercial forestry"—and pointed out some of the obstacles, important among which is taxation.

On this subject the Chamber through referendum expressed itself as follows: *"Taxation of growing timber should be based upon the principle of the yield tax with reasonable uniformity among the states in such taxation."*

Recently the Chamber's Committee on Taxation recommended that, *"There should be modifications of the Federal Income Tax Law that will recognize adequately the peculiar nature of the business of producing forest crops."* The Committee felt that *"to require those engaged in raising forest crops to take deductions annually rather than against the proceeds of the crops to which they relate is a denial of justice."*

At the Fourteenth Annual Meeting, May, 1926, the following resolution was adopted:

For reasons stated in the report of the Committee on National Forestry Policy, and in Referendum 42, based thereon, adequate conservation and replacement of our forests is not practicable without relief from present customary methods of imposing annual property taxes upon standing timber separate from the land upon which it grows. The magnitude of the public interest involved warrants the concerted efforts of responsible state, federal and private agencies to plan and to secure the general application in the states of methods of forest taxation which will effectively promote timber conservation and reforestation through private enterprise.

Results of the Ad Valorem System

In the past it has been the custom in most states to tax standing timber and other forest lands on their actual assessed value, in the same way that houses, barns, agricultural lands and other real estate are taxed. This is the ad valorem system of taxation, which is still the practice in many states. It offers no incentive for replanting and cultivating young trees and protecting them until maturity. Nor does it give encouragement to those who desire that their commercial trees shall attain full growth. In addition to risks of loss by fire and pestilence there is the certainty of a constantly increasing tax burden during the long period of years while the timber is growing. Not only does the assessed valuation tend to increase but the tax rate itself increases as other mature timber is cut off, and the cumulative burden falls on the few remaining stands.

The decline and eventual abandonment of many communities which derived their subsistence from the adjacent forest industries is one of the inevitable consequences of the removal of the forests without provision for growth. Mining communities frequently fall into decay with the exhaustion of their mineral deposits, but it seems an inexcusable waste to force our timber into the same category, when this could be obviated by recognizing that while there is only one crop of minerals many crops of timber may be harvested from the same piece of land.

Realization of these facts has produced a demand for measures to perpetuate our forests and forest industries, and particularly for the removal of the tax discriminations against forestry. It is felt that forest growing should be placed on a par with agriculture and be allowed to pay its share of the tax burden from the harvest.

The Harvest Tax System

In considering the subject of forest taxation there are certain primary requirements generally accepted. The continuing ability of a particular industry to pay taxes is directly dependent not only on its ability to create or produce but also on the actual accomplishment of the object and the conversion of the produce into a merchantable article. It is obvious that a year's growth of a tree, although it may be considered the year's income from a particular piece of land, cannot be removed and marketed to satisfy the demands of the tax collector. It is only on large forests that rotation systems can be applied and an annual revenue obtained by cutting certain areas each year. In smaller tracts, even though handled in the most modern and scientific manner, it is seldom economic to cut a few scattered trees each year. It is logical therefore that forest taxes be on the harvest or yield rather than on an annual basis.

Essential Elements of Any Forest Tax System

Comments received concerning laws of this type now in force in various states indicate that for general acceptance such laws should be simple, inexpensive, and of broad application. They mention—the desirability of administration by local authorities, with technical assistance from the state forester; extension of the benefits of the law to all lands which are handled primarily in accordance with its purposes; freedom for owners to withdraw their lands from the special forest tax classification without incurring heavy penalties; arrangement of tax payments with the minimum annoyance to the payer; and consideration of the need of the community for annual revenue to support the local government.

Forest Service Activities

The problem of equitable and constructive taxation of the forest industries has been under consideration for a number of years, and a satisfactory solution will require considerable further study and

State	Forest Lands		Lumber & Timber Products	TAX SYSTEM					Status of Tax Reform Measures
	Area 1000 acres	Per cent of State	$1000	Ad valorem	Yield or Severance	Exemptions	Limited Valuations	Bounties	
Ala.	20,000	60.1	52,792	*	*	*			
Ariz.	5,350	7.3	4,186	*					
Ark.	21,500	64.0	73,468	*	*				
Calif.	16,761	16.5	86,959	*					Const. Amendment pending.
Colo.	8,682	13.0	1,209	*		*			
Conn.	1,451	45.7	1,589	*	*				
Del.	350	23.1	683	*					Forestry Com. making study.
Fla.	19,000	50.7	45,150	*					
Ga.	20,000	52.8	30,037	*					"Contract Law" failed 1925.
Idaho	16,361	30.4	39,478	*					Forestry Board created 1925.
Ill.	3,148	8.7	5,096	*				*	Const. Amend. failed in 1922.
Ind.	3,500	15.0	14,712	*			*		Minor amendments pending.
Iowa	2,314	6.4	958	*			*		
Kan.	small			*			*	*	
Ky.	9,400	36.2	15,375	*					Yield Tax bill pending.
La.	17,365	50.1	132,682	*	*		*		Yield Tax bill pending.
Me.	14,000	66.4	20,162	*	*	*			
Md.,	2,228	28.3	3,538	*					
Mass.	2,241	42.4	4,946	*	*				
Mich.	18,400	49.6	50,097	*	*				Yield Tax Law enacted 1925.
Minn.	20,900	40.4	28,191	*				*	Const. Amendment pending.
Miss..	17,000	57.3	92,033	*	*				Bill pending to amend law.
Mont.	13,926	14.8	13,197	*					
Me.	13,820	31.4	13,246	*					
Neb.	small			*			*		Gov. may make recommendations to next legislature.
N. H.	3,944	66.0	13,300	*		*			
Nev.	484	0.7		*					(Very little *private* forest land).
N. J.	2,000	38.0	639	*					
N. M.	5,550	7.0	3,090	*					
N. Y.	12,100	38.4	15,406	*	*				
N. C.	18,000	57.7	38,051	*					
N. D.	small			*	*				
Ohio	4,000	15.2	8,967	*	*				Yield Tax Law enacted 1925.
Okla.	8,000	18.0	4,637	*					Forestry Com. created in 1925
Oreg.	23,275	37.6	140,538	*					Forest Com. making study.
Penn.	12,000	41.5	13,681	*	*				
R. I.	280	35.0	121	*		*			
S. C.	10,000	51.2	29,257	*					
S. D.	1,173	2.4	1,383	*				*	
Tenn.	12,000	44.6	35,066	*					
Texas	15,000	8.6	51,879	*					Ref. failed in Legislature.
Utah	3,600	6.6	58	*					(Very little *private* forest land)
Vt.	2,792	45.6	6,639	*	*	*			
Va.	12,000	44.0	25,427	*					
Wash.	17,550	39.6	290,667	*					Const. Amendment pending.
W. Va.	8,550	55.4	28,727	*					Forest Com .making study.
Wis.	17,800	49.6	53,485	*		*			Const. Amendment pending.
Wyo.	5,716	9.1	1,231	*				*	(Very little *private* forest land)

experimentation. Leadership in this work is being taken by the federal government and the Forest Service is to be given an appropriation of $25,000 a year for study. The investigation has been placed under the direction of Professor Fred R. Fairchild, of Yale University, an eminent authority. The first activity will be an intensive survey of certain districts in the United States to determine the extent of the tax burden and its effect on the business of reforestation. Following this, studies will be made of the forest tax systems here and abroad. This information will be made available to all interested. But beyond this the federal government cannot go—the taxing of forests being entirely a state matter.

State Activities

Direct encouragement to tree growing has been offered by several states through bounties, exemptions, and limited tax valuations. None of these has been particularly effective, nor has the principle of such subsidies been favorably viewed by the taxpayers. Furthermore the *producer is not requesting bounties or special favors but merely that the handicaps under which he is now laboring be removed.*

In summing up the present status of the forest taxation situation throughout the country, it is found that while nearly half the states in the union have some sort of special laws to encourage the growing of trees, only in a very few instances are those laws accomplishing their purpose. Information which the department has received from various parts of the country indicate that considerable attention is being given this subject in at least twenty-seven states. In twelve, definite movements are under way for the introduction and passage of special forest taxation relief laws. Among these are California, Washington, Minnesota and Louisiana, which have constitutional amendments pending for referendum vote in the coming fall to permit special taxation measures for forests and forest products.

Forest Areas and Forest Tax Laws in the States

The importance of the forests in the various states and the efforts made to improve conditions through tax legislation are shown in the accompanying table.

Washington, Oregon, and Louisiana are the three great lumber states, as judged by present production, but there are a dozen others which each produce annually lumber and timber products valued at over $30,000,000 according to the 1923 census of the lumber industries. The total of a billion and a half for the whole country would be considerably increased if the value of the pulpwood, naval stores, fuel and other products were added.

An idea of the potential forest assets of each state may be obtained from the column showing the total forest areas. This data is taken from the "Capper Report" prepared by the Forest Service pursuant to Senate Resolution 311 (66th Congress, 2nd session). It should be noted that Oregon, Arkansas, and Minnesota have the largest forest areas and that half of our states have forests covering over ten million acres.

The interest of various states in the forest situation cannot be gauged entirely by the value of the annual products or by the acreage of the forests. In many of the smaller states a considerable proportion of their areas is classified as forest lands—for example, Delaware, 23 per cent; Rhode Island, 35 per cent; Connecticut, 46 per cent. In fact over half of the states devote at least a third of their lands to forests while two-thirds of Maine, New Hampshire, and Arkansas are put to this use.

YIELD TAXES AND OTHER METHODS OF ENCOURAGING FORESTATION

The "yield tax" is a method of raising revenue designed to be fair to the growers of forests. Its advantage lies in its tendency to bridge the non-productive growing period by lifting the burdensome annual tax from the shoulders of the grower, permitting payment of his share for government maintenance when he harvests his mature trees, and has the money to pay with.

Other methods of encouraging forestation are by bounties, by exemptions from taxation, and by limiting the tax valuations.

In the following paragraphs are given the principal elements of the systems of forest taxation with examples of the application in representative states.

Purposes

Yield and similar taxes have been enacted for a variety of reasons. Usually, the aim is to put to some useful purpose lands which at present are producing nothing and which are even in some cases a liability and danger. Other objects are, to provide forest areas without putting the state to the expense of buying the ground, such areas serving to protect the watersheds and headwaters of streams;

to prevent floods; as refuges for game and birds; as recreation areas and scenic improvements; to provide commercial forest reserves which will serve as the basis for permanent forest industries; to provide local fuel and timber supplies; and to shade and beautify highways.

Administration

Supervision and administration of these laws rests with the State Conservation Commissions, Forestry Commissions, State Foresters, State Land Agent, County Commissioners, County Assessors, or Township Assessors. Procedure varies in different states, but as a rule the detailed work is left to the local authorities, while technical knowledge and guidance is supplied by some state representative. A board of appeals is sometimes provided which passes on questions of fact when the property owner and the local authorities disagree.

Methods of Procedure

The law in many states provides a special "classification" for forest lands which can receive special consideration as regards taxation. This classification may be as "auxiliary state forest," "auxiliary forest land," "forest land," "commercial forest reserve," or "classified land."

The property owner applies to the proper authorities for classification. His land is inspected, if it meets the requirements is accepted, and the proper entries are made on the general tax list. In some states the governor enters into contract with the land owner whereby the latter agrees to grow timber on his land under the supervision of the state forester, and the governor, on behalf of the State, agrees to grant certain tax benefits. The advantage of the contract is that it cannot be affected by a repeal or change in the state's tax law.

Kinds of Land Which May Be Classified

As compared with usual methods of taxation, yield tax laws aim to stimulate the reforesting and return to production of "cut over" and other waste and denuded lands which are not profitable for other uses. It is not the purpose to divert agricultural, grazing, suburban or other lands to forest uses. Nor is it intended as a cover for the withdrawal of valuable real estate from legitimate taxation, or as an aid to speculation in forest and other lands. For these reasons there are limitations as to the value of such lands at the time of classification. Sometimes only land which is assessed at not over $5.00 per acre may be classified. In Connecticut, the land, exclusive of the timber, must not be worth over $25.00 per acre. In Massachusetts, the land and growth must not be valued over $25.00 per acre.

Most states provide that the land shall be suitable for growing trees and that a start has been made to grow them.

In Maine, the classification is open to all private lands covered with trees or which will be reforested. Pennsylvania broadly offers classification to any land devoted exclusively to growing trees.

Since the purpose is to grow trees, some states prohibit grazing in these tracts. Occasionally stipulations are made as to the kind of trees which may be grown but usually this is left to the discretion of the owner.

Recognizing that it takes a number of years to bring fruit and nut bearing trees into production several states have applied the yield tax principle to this class of growth.

Density of Planting

Since it is the usual custom to have all lands inspected by a forester or other experienced person before classification is granted, most states do not consider it necessary to legislate concerning the details of planting and cultivation of trees. Michigan, for instance, simply provides that the land must have a sufficient forest growth, through planting or natural reproduction, to give reasonable assurance that a stand of merchantable timber will be developed. Some states are more particular. In Massachusetts, the land must be so stocked as to give promise of yielding 20,000 board feet of softwoods, or 8,000 board feet of hardwoods per acre. New Hampshire raises the minimum limit to 25,000 board feet per acre. Vermont requires 1,000 trees per acre or sufficient to assure a 6 feet by 6 feet spacing over the entire area. Ohio is content with 680 trees per acre. New York permits classification if the land is planted with 800 trees per acre, or underplanted with only 300 trees per acre.

Size of Areas

While several states provide minimum area limits such as 3 acres in Ohio; 5 acres in Connecticut and Vermont, and 5 acres in New York, very few states provide maximum limits; although New Hampshire places a maximum of 100 acres per township for each owner.

As a rule it has been found that the regulations concerning the kind of land which may be used make stipulations as to size of areas unnecessary.

The early tendency was to permit only small tracts such as groves and woodlots to obtain benefits under these laws. Recently there is a growing appreciation of the inadequacy of these provisions, and of the necessity of extending the law to include large areas essential to commercial forestry.

Duration of Classification

It is seldom considered necessary to place minimum limits on the period of classification although Alabama classifies for a least five years and as much longer as is desired.

A few states consider it advisable to limit the period during which the benefits of the yield tax classification may be obtained. In Louisiana the contracts are drawn for 20 to 40 years. The proposed law for Mississippi would place the maximum at 50 years. In Connecticut benefits may be obtained for 100 years.

Several states require that the timber be cut as it matures and that replanting be done. In Massachusetts and New Hampshire the forests must be thinned out when they are estimated to carry over 25,000 board feet to the acre.

In some states no maximum limits are stipulated as it is realized that the desire to recover his investment will induce an owner to cut his timber as soon as it has matured sufficiently. In fact the general tendency is to cut it even sooner.

Termination of Classification

Classification may be terminated by voluntary withdrawal by the owner, by compulsory withdrawal because of non-fulfillment of requirements, or by expiration of the period for which classification was granted.

Often the full yield tax is collected at the time of termination in spite of the fact that the timber has not been cut. This is the law in Alabama, Massachusetts and several other states. In Louisiana and New Hampshire the property is returned to the general tax list and the taxes for the current year are collected. In Ohio the forest may be withdrawn at any time but the taxes which have been avoided by classification must be paid up with interest. Back taxes for more than ten years, however, cannot be collected; and if the land has been classified for more than 25 years no charges are made for withdrawal. Michigan permits withdrawal at any time upon payment of a fee for the period of classification. This fee amounts to 5 cents per acre per year for the first fifteen years, and 10 cents per acre per year for the next ten years. For any period over 25 years the fee is 30 per cent of the stumpage value. Apparently, the theories in Michigan and Ohio are in opposition as to the benefits resulting to the state and the individual from long-term classification.

In Alabama, failure to keep the contract makes the owner guilty of a misdemeanor and liable for the yield tax on the appraised value of his timber.

Annual Taxes

In states where some form of yield tax is in force, the principle of separating the land and the timber crop for purposes of taxation is recognized and the annual land tax is usually nominal. It is customary to stipulate that the timber be disregarded and that only the land be taxed and that this land tax shall not exceed a certain sum per acre or that the valuation on which the tax is assessed shall not exceed a certain sum. This enables the owner to forecast the actual tax cost of carrying his forest during the growing period.

In Michigan the land-growing pine is taxed 5 cents per acre and hardwood land 10 cents per acre each year. Pennsylvania places a valuation of $1.00 per acre on such land for annual taxation purposes. In Louisiana the valuation is from $3.00 to $8.00; Maine, not over $5.00; Vermont, not over $3.00.

Within these maximums the valuations of classified forest lands are fixed by the local assessors and the law usually states that the valuation shall be the same as for other barren or unproductive lands. Ordinarily the tax rate is the same for all classes of real estate within a county or township, but occasionally, as in Connecticut, the tax rate for classified forest land is fixed on the valuation of land and timber at the beginning of a fifty-year period, during which it cannot be increased, and the local tax rate is limited to 10 mills. A few states provide special tax reductions on this class of lands. In Ohio the tax is only 50 per cent of the local rate and in New Hampshire as much as 90 per cent of the tax is rebated on certain classes of land.

Taxing the Harvested Crop

Yield taxes and severance taxes are based on the value of the timber when the cutting is made.

Some states have a graduated tax which increases with the length of the period that the forest has benefited, while others charge a flat rate without regard to the period of protection. A few combine the two methods.

In determining the yield tax there are a number of factors, such as the annual tax, the rapidity of growth, the quality of the timber and the value of the land which must be taken into consideration. Consequently, there is a wide variation in the tax levied by different states. In Ohio the tax is 5 per cent; Massachusetts and New York, 6 per cent; Alabama, Louisiana, Pennsylvania, and Mississippi, 10 per cent; Michigan, 25 per cent.

In Maine the tax is levied on a graduated scale depending on the length of time the land has been classified. During the first year the tax is ½ per cent and it increases a similar amount each year until the tenth when the tax remains fixed at 5 per cent.

Vermont collects a 10 per cent tax on cuttings on young timber lands, but when timber is cut on waste and wild forest lands, where the growth was over 15 years old when classified, the tax amounts to 1/10 of 1 per cent for each year of classification with a maximum of 7 per cent. The Connecticut law is somewhat the same. Timber which get its start under the yield tax law pays a 10 per cent tax, but timber which was at least 10 years old when classified pays a 2 per cent tax if cut within 10 years and an additional 1 per cent for each decade of protection, the maximum tax being 7 per cent for 50 years or over.

Exemptions from tax: Timber cut for personal use such as fuel, fences, and other domestic purposes is usually exempt. Some states place a limit on the amount which may be cut. In New Hampshire timber up to $50 per year is exempt and in Massachusetts up to $25.

In Pennsylvania and Vermont, timber cut in order to thin out the forest and maintain a healthy growth is exempt.

In Maine, there is no tax on cutting small timber such as pine under 16 inches in diameter, measured at 4 feet above ground, and spruce, hemlock, or cedar 12 inches or less in diameter.

Collection of Taxes

Annual and yield taxes on timber lands, timber and other forest products are due and collectible in the same manner as other town, county and state taxes. They are subject to the same laws and processes of collection.

The laws of most states are sufficiently stringent on the subjects of fraudulent returns and neglect of tax payments to give adequate protection; and so as regards yield and severance taxes, the modern tendency is to eliminate as much red tape as possible and to arrange payments with the minimum annoyance to the taxpayer. In Massachusetts and New Hampshire the tax is paid annually; in Maine six months after cutting. Michigan and Pennsylvania collect within 90 days; Mississippi within 60 days. On the other hand, New York, Connecticut and Vermont levy the tax before the timber is removed.

Many states require that the timber be inspected and valued by a representative of the tax collector before it is moved from the ground.

Michigan requires that a bond amounting to twice the estimated tax be deposited before cutting is started.

Compensating Local Governments for Loss of Annual Revenue

The establishment of federal and state forest reserves and the removal of these areas from the general tax list sometimes results in a considerable loss of revenue to the state, county, parish, or township. Naturally this has caused opposition in certain quarters. Similar objections have been raised to the classification of lands for yield tax purposes and the reduction of annual revenues from these lands to nominal amounts.

The objection has been met by turning over to the local government all or a large proportion of the yield taxes collected. In Pennsylvania it is all credited to the town and county road, school and poor funds. In Massachusetts, the state takes one-tenth of the tax and the rest goes to the town. In Michigan the yield tax funds are divided equally between the state and county, and in addition the county receives from the state 5 cents per year for each acre classified. Alabama and Ohio return to the counties one-half of the yield tax receipts.

Bounties

The desirability of trees and forests was recognized first in states having large prairie areas, and it was felt that definite steps must be taken to encourage the production of local timber and fuel supplies and to provide for the protection, shading and beautification of the highways. During the latter part of the past century this encouragement took the form of bounties in a number of the Middle Western states. These bounties amounted, at most, to $10.00 per acre, and often were considerably less. As it was not the object to stimulate large operations, the period was usually limited to five or six years, and the area often to ten acres. Some of these old bounty laws are still on the statute books, but none of them has been particularly effective.

Exemptions

Stimulation of interest in developing forest tree plantations has been attempted by several states through tax exemptions. These range from total exemption from taxation on both the land and growth to a partial exemption on the value of the growth.

It is customary to limit the exemption to a definite period, 20 to 35 years, which roughly corresponds to the time required to mature young timber. At the end of the period the property is returned to the general tax list. Occasionally the area is limited to 50 or 100 acres, and the class of land is usually confined to that of little or no value—$5.00 or $10.00 per acre. Usually lands close to villages and towns are not permitted to claim the exemption because they have potential value as residential property.

Limited Tax Valuations

Another of the earlier methods of encouraging the growing of trees is the limiting of the value for tax purposes of any tract devoted solely to this use. This type of law is used in several states. The valuation is usually fixed at $1.00 per acre but sometimes the law merely provides that there shall be no increase in the valuation because of the trees growing on the property. Often there are the usual restrictions as to area, period, and class of land.

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THE INCREASING IMPORTANCE OF SPECIAL TAXES

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PRESENTED AT THE SEVENTEENTH NATIONAL TAX CONFERENCE
HELD AT ST. LOUIS, MO., SEPTEMBER 15–19, 1924

NATIONAL TAX ASSOCIATION
OFFICE OF SECRETARY
195 BROADWAY, NEW YORK CITY

franchises, gasoline or consumption taxes and taxes on receipts from production or severance taxes.

But the census report groups separately "poll taxes" and "business taxes," the latter being defined as taxes "upon business and business activities exacted from persons, natural or corporate, (1) in proportion to the volume of their business, (2) by reason of the business in which they are engaged, or (3) by reason of some activity which constitutes a part of their business."

Additional major sources of revenue are combined under the head "non-business and license taxes," and described as "taxes, other than upon businesses, that are exacted primarily for the purpose of regulation and are collected in connection with the issue of so-called licenses or permits," with reference to measurable or assumed benefits conferred upon the licensees. Representative of this class are dog licenses, marriage licenses, building permits, motor vehicle licenses, etc., not to suggest, let us hope, a necessarily progressive series or a natural sequence, in which these ultra-modern "satisfactions" are normally demanded—dogs, wedding-bells, bungalows and limousines.

The final classification of the census bureau is "special assessments" and "special charges for outlay," the former being described as "compulsory contributions levied under the taxing or police power, to defray the costs of special public improvements or public services undertaken primarily in the interest of the public."

It is explained that special assessments differ from general property taxes in that they are apportioned according to assumed benefits to the property specially affected by the improvement, or assumed benefits to individuals or corporations by reason of the special service performed.

In this paper, however, the terminology of the census bureau will not be followed to its ultimate refinements; but the term "special taxes" is used herein in a broader sense, and as comprehending all levies other than those imposed *ad valorem,* on property in general. It will, for the purpose of the comparative analysis proposed by this discussion, explicitly include taxes for local improvements, which confessedly are technically "special *assessments,*" and not *taxes* at all.

GENERAL TAXES FOUND INADEQUATE

The general property tax originated and found its most suitable application in an agricultural stage of economic growth, when the mass of property was tangible and but slightly differentiated. Until within the last fifty years the general property tax was nearly everywhere preeminently the source of all public funds. But beginning about the middle of the nineteenth century, with the impetus given to industrial development by the adoption of the corporate form of business organization, a natural quest arose for the most effective machine to reach this new kind of property, which to such a marked degree was intangible and invisible.

Special taxes had already been devised for banking and insurance companies, the earliest development being in New Jersey in 1910, with a law requiring the president of specified banks to pay into the state treasury one-half of one per cent on the paid-up capital stock.

THE HUMBLE POLL TAX

The obnoxious poll tax centuries ago had been the cause of Wat Tyler's Rebellion, and since 1698 has been unknown on British soil; yet we find it retained as a persistent though inconspicuous revenue feature in forty-three of the American states. There has been a distinct trend, however, to allocate or identify it with the suffrage right, so that in point of practice the $1 poll tax has come to be regarded by many as the price of the sovereign right to vote!

TAXES BASED ON GROSS RECEIPTS

In 1862, Iowa adopted a tax on gross receipts of railroads; and the New York Corporation Tax Law of 1880 was a further departure from the old inflexible system. The New Jersey act of 1830 imposed a tax based upon the number of passengers and tonnage of freight transported, which was changed in 1849 to a tax at a fixed percentage of the cost of all roads having a net income of six per cent or more. The United States Supreme Court sustained the Minnesota tax on gross receipts of foreign express companies.[1]

A conspicuous example of a special tax is that of 7% of its gross income imposed on the Illinois Central Railroad, by the Act of 1851. Under this law, the company pays semi-annually to the State of Illinois, in lieu of property taxes, an amount ranging from $1,000,000 to $1,500,000 a year.

In Pennsylvania the special tax on capital stock yielded, all told, in 1909 nearly $10,000,000, probably then the most productive single tax levied in any of the states, but surpassed by its 1922 performance of $20,493,882.

THE ULTRA MODERN GASOLINE TAX

The tax of four cents per gallon on gasoline, together with the schedule of license fees imposed in Arkansas by the Harrelson Highway Act,[2] has yielded during the first year of its operation nearly $5,000,000, or a sum in excess of the entire regular *ad valorem* levy for all state purposes, at 8.7 mills. And the new law imposing a tax on cigarettes and cigars[3] stands to bring to Arkansas around $150,000 a month—a figure astounding indeed to one who was never initiated into the delights of the aromatic weed.

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[1] *State* v. *U. S. Express Co.*, 114 Minn. 346; 131 N. W. 489; aff'd in 223 U. S. 335.

[2] Approved Oct. 10, 1923; Special Acts, 1923, p. 11.

MORTGAGE REGISTRATION TAX

The New York mortgage tax of 1906 levied a recording tax upon mortgages at a low rate (now 50c. for each $100 of the principal debt), and provided for the exemption of secured debts, after the initial payment of the mortgage tax. The New York scheme has been copied with success in several other states, including Kentucky, Alabama,[4] Minnesota[5] and Oklahoma,[6] but was declared unconstitutional in Kansas.[7]

In Maryland a low flat rate is levied on the value of certain securities which, under the regular rate applicable to property in general, had gone into hiding and escaped the assessor. In 1896 only $6,000,000 of such securities were reflected on the tax books. Under the new law, with a fixed rate of 4½ mills on this class of property, the assessed valuation began steadily to increase, until in 1919 it amounted to more than $208,000,000.

NEWER FORMS OF SPECIAL TAXES

The federal excise tax, a time-honored resort, but which leaped into unparalleled importance as an incident to the World War, showed a total yield of $115,546,248 upon motor vehicles alone for the year 1921. To enumerate the other familiar articles upon which the "miscellaneous tax" has been laid by the Federal Government with resistless crescendo, would unduly burden this discussion and arouse reflections of an exceedingly unpleasant cast.

INHERITANCE TAXES

The most universal example of special taxes consists of the inheritance tax laws now in force in forty-six states and the Federal Government, not to mention their astonishing expansion abroad. In 1913 the total yield from this tax in all the states was $26,000,000, or less than one-fifth the sum Great Britain raised from death duties in that ominous year from whence the luckless world plunged into the abyss of cataclysmic war. The decade just ended recorded a pyramidal increase in America, so that the latest annual yield of inheritance taxes — $210,000,000 — equals eight times the earlier stupendous total of $26,000,000.

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[3] Act No. 4, Special Session of 1924, approved June 30, 1924.

[4] *State* v. *Ala. Fuel & Iron Co.,* 188 Ala. 487; 66 So. 169.

[5] *Orr* v. *Sutton,* 119 Minn. 193; 137 N. W. 973.

[6] *Trustees* v. *Hooton,* 53 Okla. 530; 157 Pac. 293.

[7] *Wheeler* v. *Weightman,* 96 Kans. 50; 149 Pac. 977.

The states and the Federal Government are verily in unseemly contest over this disputed source of revenue; and Alabama and Florida are said to be the only states which have steadfastly refrained from leaping into this glittering band-wagon headed towards the side-show of " easy money ".

The rapid increase in the yield of inheritance taxes in the jurisdiction in which this meeting is held (Missouri), and in several neighboring states, in New York and the federal estate tax (which began in 1917), is shown by the following table:

INHERITANCE TAXES

	1903	*1913*	*1922*
Arkansas	$ 302	$ 23,665	$ 308,492
California	290,447	1,586,875	6,344,644
Illinois	503,816	1,612,818	3,367,041
Iowa	147,332	280,733	689,486
Missouri	229,854	479,517	1,374,883
New York	3,303,555	12,153,189	15,431,481
Pennsylvania	1,300,834	2,038,738	11,332,935
Federal estate tax			139,418,846
Total federal and all states	7,038,684	26,470,964	207,546,905

INCOME TAXES

The income tax law, while a later development as a state device, bids fair to outstrip the inheritance tax in point of yield. A few examples suffice to show the importance of this source for the latest year for which returns are available:

Arkansas	$250,000
Connecticut	775,000
Delaware	289,000
Massachusetts	12,586,000
Mississippi	38,000
Missouri	2,865,000
Montana	113,000
New York	14,900,000
North Carolina	3,976,000
South Carolina	1,041,000
Wisconsin	4,178,000

MOTOR VEHICLE TAXES

The phenomenal increase in motor vehicle taxes is vividly shown in the following data, prepared by the National Industrial Conference Board:

	1913	*1923*
Indiana	$ 92,386	$5,215,923
Iowa	717,229	7,891,366
Illinois	482,866	9,441,775
Michigan	185,392	9,572,857
Minnesota	38,834	7,215,121
Ohio	396,504	9,981,434
Wisconsin	187,376	4,791,158

A recent article in the Chicago *Journal of Commerce* treats of the increase in gasoline consumption in twenty states, having either a gasoline tax law or a gasoline inspection law. The total for the six months ending June 30, 1924, of 946,110,715 gallons compares with 779,449,667 gallons during the corresponding period of 1923, or an increase of 21.4%, while the increase in the single month of June, 1924, over the preceding month of May is 9.3%.

The number of states that do not levy some form of gasoline tax is small, including, as of August 1, Missouri, her four neighbors, Illinois, Iowa, Kansas and Nebraska, and nine others. In Michigan, Iowa and Wisconsin bills passed to impose such taxes have been vetoed by the governor, through the activities of motorists who claimed that they were already excessively burdened, and that the additional taxes on gasoline were not needed to build roads, since this expense is adequately cared for by license fees.

The principle underlying the gasoline tax as a tax upon the privilege of using the commodity as a fuel in motors on the highways of a state, was, so far as I am informed, first ruled in Arkansas in 1922[8] and the principle has recently been upheld in the highest court of the land.[9]

SEVERANCE OR GROSS PRODUCTION TAXES

The severance or gross production tax is a development of the past decade,[10] and comparisons with 1913 cannot of course be

[8] *Standard Oil Co.* v. *Brodie,* 153 Ark. 114; 239 S. W. 753.

[9] *Pierce Oil Corpn.* v. *Hopkins,* 282 Fed. 253; aff'd in 264 U. S. 137.

[10] Leading cases upholding this form of special tax include:

Republic Iron & Steel Co. v. *State,* 204 Ala. 469; 86 So. 65.
Floyd et al. v. *Miller Lumber Co.,* 160 Ark. 17; 254 S. W. 450.
Ark. R. R. Commission v. *Stout Lumber Co.,* 161 Ark. 164; 255 S. W. 912.
Oliver Iron Mining Co. v. *Lord et al.,* 262 U. S. 172.
Re Wolverine Oil Co., 53 Okla. 24; 154 Pac. 362.
Heisler v. *Thos. Colliery Co.,* 274 Pa. 448; 118 Atl. 394; aff'd 260 U. S. 245.
Producers Oil Co. v. *Stephens,* 44 Tex. Civ. Ap. 327; 99 S. W. 157.
Texas Co. v. *Stephens,* 100 Tex. 628; 103 S. W. 481.
Southwestern Oil Co. v. *State,* 100 Tex. 647; 103 S. W. 489.
Gulf Ref. Co. of La. v. *McFarland,* 154 La. 251. 97 So. 433.
Ark. Nat. Gas Co. v. *McFarland,* 154 La. 266; 97 So. 438.

made. The fact, however, sticks out that a total yield of $30,000,000 has been found from a brand-new fountain head—further evidence of the common trend. Round figures for the latest fiscal year include:

Alabama	$1,000,000
Arkansas	1,000,000
Louisiana	2,500,000
Minnesota	6,000,000
Oklahoma	8,000,000
Pennsylvania	8,000,000
Texas	5,000,000
West Virginia	3,000,000

TAX ON INSURANCE COMPANIES

The special tax paid by insurance companies is based in most states upon a percentage of gross receipts on premiums collected within the state; and the following comparisons reflect the significant growth:

TAX ON INSURANCE COMPANIES

	1903	*1913*	*1922*
Arkansas	$50,000	$220,000	$440,000
Michigan	374,299	616,000	1,685,689
Missouri	164,825	624,578	1,547,518
Minnesota	284,573	443,235	1,113,216
Iowa	237,742	390,549	1,096,085
New York	1,166,528	2,104,743	5,052,020
Illinois	311,380	519,869	3,530,121
Wisconsin	460,810	759,556	1,261,533
All states	6,475,540	17,554,971	

Finally, as a graphic showing of the steady increase in the utilization of special taxes for state as distinguished from local requirements, the following table is gleaned from the census advance report on "Financial Statistics of States," at page 20:

Percentage of total revenue receipts obtained for state purposes from—

	General Property	*All Other Sources*
1915	40.6	59.4
1916	37.7	62.3
1917	34.9	65.1
1918	35.6	64.4
1919	35.1	64.9

The showing is all the more remarkable because of the retarding influence of the enormous revenue loss due to the abrupt abolition of liquor licenses, since the adoption of the 18th amendment to the Federal Constitution.

From the financial statement of experts, the cost of this tunnel will be amortized in eleven years and at the end of twenty years there will be an accrued surplus to each state of $33,635,000, in addition to securing the tunnel without cost to the people.

The improvement will pay for itself through the tolls to be levied upon traffic, this plan amounting in the long run to a "special tax," since financing by means of tolls is but another method of paying for public improvements.

FINANCING OF IRRIGATION AND DRAINAGE VIA SPECIAL TAXES

The irrigation districts of the West constitute valuable public facilities financed under the plan of special improvement taxes.

In the California procedure, typical of the system throughout the country, organization is perfected by the filing with the board of supervisors of the particular county of a petition of land-holders within the boundaries of the proposed district. Thereupon an election is held to determine whether the district shall be created and for the election of directors.

Provisions for the issuance of bonds usually appear, and in most cases bonds can only be issued upon an affirmative vote of the electors within the district.

A remarkable case of a special improvement on an ambitious scale is that of the Moffat tunnel, penetrating James' Peak in Colorado. The Moffat Tunnel Improvement District was created under an Act of the Special Session of the General Assembly called by Governor Shoup in 1922, which also enacted a flood control law, following the precedent of the Ohio Conservancy Act.

Says Mr. Erskine R. Myer, attorney for the Moffat Tunnel Commission:

> "The general principles underlying the Moffat law are simple. The legislature of any state has what is known in legal parlance plenary power. In other words, the legislature may do any act which the people of the state may do, if that act is not prohibited by the constitution. Therefore, the legislature had the right and exercised it, in the passage of this bill, to form a special improvement or tax district, for the purpose of constructing a public improvement, to-wit: the Moffat Tunnel.
>
> "It was called 'an avenue of communication,' and the purposes to which it could be put were railroad uses, transportation of water, transportation of vehicles, for the transmission of power, and for telephone and telegraphic messages."

The legality of the project was put to judicial test and the law held constitutional by the United States Supreme Court.[14]

[14] *Milheim* v. *Moffat Tunnel Imp. Dist.*, 72 Colo. 268; 211 Pac. 649; aff'd in 262 U. S. 710.

PROMOTION OF CIVIC PRIDE THROUGH ESTHETIC DEVELOPMENT

Another Colorado project of moment is that authorizing the Denver Civic Center and the several beautiful parks within and adjacent to the "Queen City of the Plains". Assessment for the cost of acquiring land for these states and for the Civic Center was made against all the real estate in each park district of the city, which was divided into thirty-eight zones. The assessments ranged from $3 to $1100 per lot. The boundaries of the zones and the amounts apportioned to the several lots were fixed by the park commission, acting as an assessment board.

We have briefly noted the increasing volume of revenue derived each year from what has been termed "special" sources, in contradistinction to the mass of property in general, which remains the chief dependence, because of its familiar appearance in every taxing district.

SPECIAL SOURCES MAY AID BUT NOT SUPPLANT THE GENERAL LEVY

The fact sought to be emphasized in this review is that "special" sources of revenue are indeed a real and eligible dependence as a supplemental and auxiliary resource; but by no means can they be relied upon, at this stage of economic progress, as a substitute for the general property tax.

Incomes, polls, inheritances, franchises, excises, production taxes, consumption taxes, and the rest of the "awkward squad" have, through dire need, been widely requisitioned, and they are obviously registering progress. But to the old guard — the well-marshaled forces under command of old Gen. Property Tax, must we look for years to come for the indispensable sinews of war.

In the face of a dismal prospect of over-population and race-decline, as forecast by certain eminent scientists, Arthur Brisbane, who is more of an economist than a dreamer, recently declared that the State of Texas alone could, under intensive cultivation, feed the earth's entire present population of 1,600,000,000. And far from race-extinction through sheer pressure of existence, he ventures the prediction that the next centennial will find in this country "a thousand million human beings, infinitely happier, richer and better off in every way than any population that has ever lived."

RATIONAL DEVELOPMENT IN PROSPECT

Indeed, it does not take a Brisbane, a Bellamy or a Wells to discern the universal shifting of world affairs from the abstract to the concrete; from the general to the special. The decennium now just receding into the fateful scroll of history has recorded tremendous changes, for the most part we trust, conducive to the amelioration of mankind. What has been wrought during these aptly termed "eventful years" is but a harbinger of a rational and sure development which lies immediately ahead. And in no field is there greater need for broad as well as intensive cultivation than in the hitherto neglected domain of public finance.

The general property tax remains a sturdy survivor of conditions which brought it forth long in advance of the present era of twentieth century civilization. It is still the backbone of the revenue resources of the local community in all the states. Yet, as we have seen from this cursory survey, there is an unmistakable craving for new and specific subjects of taxation—definite sources of public funds, that bear more or less direct relation to the governmental function to which the funds so sought are to be applied.

TAXES TO FIT SPECIAL GOVERNMENTAL FUNCTIONS

The allocation of special taxes to special functions, such, e. g., as the motor tax to the maintenance of highways,[15] will not only identify in the public mind the relative desirability of our various public necessities, but the appropriate method of their financing as well. Moreover, it will automatically release *pro tanto,* property in general, thus paving the way for just recourse to an *ad valorem* levy for funds to meet expenses of rural localities whose revenue sources are obviously limited and few.

It is unwise to close our eyes to proposed innovations, upon the ground that safety lies only in conservatism. A broader patriotism as well as obedience to the scriptural injunction will prompt us to "prove all things, and hold fast that which is good."

Finally, there is a certain degree of safety in "following the crowd," even in taxation schemes. Witness the gasoline tax, which was at first condemned, on the pretext that a consumption tax would be futile, since its successful evasion would require merely crossing the state line to fill one's tank at a non-tax station. But the rapid spread of the new device soon made that argument obsolete. Legislators everywhere seemed to revive in riotous refrain the ditty of a generation ago:

> "There's no use talking, no use talking;
> Its just so everywheres.
> If you do as the folks of the fashion do,
> You're bound to put on airs!"

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[15] According to Mr. John E. Walker, former tax advisor to the U. S. Treasury, 36.3% of the $337,546,248 collected as special motor vehicle taxes in 1921, was available for highways.

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TAXATION OF NATURAL RESOURCES

GEORGE VAUGHAN
Little Rock, Arkansas

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TAXATION OF NATURAL RESOURCES

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Little Rock, Arkansas

1. *Introductory*

By the term Natural Resources is comprehended all that mass of economic goods or available benefits which are the direct heritage of the race—those basic bounties originally bestowed by a munificent Creator upon the children of men.

The processes by which natural resources have come into existence are superhuman as distinguished from the artificial products fashioned by the hand of Man, whose dominion over "the earth and all the things that therein are" is as ancient as it is unchallenged.

Natural resources in the present state of society may be divided into two generic classes. The first class includes those unappropriated benefits, more or less widely diffused, which are owned collectively by the community at large. To this class belong a wholesome water-supply, a salubrious climate, propitious seasons and the cosmic urge of a conquering race. To the second class belong those resources of a physical nature, such as superior coasts and harbors, valuable inland waterways, magnificent watersheds, inviting development of enormous hydro-electric power, also extensive deposits of ores, of coal and precious metals, and finally the virgin forests, capable if duly conserved, of promoting the comfort and protection of generations yet unborn.

The last named class alone—physical products of nature—may be further subdivided into: (1) alienable and consumable, and (2) non-alienable and indestructible. It is to the sub-class—alienable natural resources—that any question of taxation germane to the present conference can properly relate. It shall, therefore, be my purpose to confine this paper, which must be in briefest outline, to those methods now extant, of taxing basic and non-reproducible resources, found under private ownership, as the resultant alone of the slow and imperceptible processes of nature.

At the outset, then, let us note that the subject-matter of our present inquiry is essentially a wasting asset. The supply of these resources, though vast, is limited. Many of them have been accumulated by the gradual operation of natural forces through the centuries of a prehistoric age; yet though "rock-ribbed and ancient as the sun," they are susceptible of rapid depletion and waste. And when they are gone, society has sustained a loss, irretrievable and complete.

We need not here assume, however, the extreme position of advocating a prohibitive ban, under the guise of a tax. To restrain extravagant extraction of mineral deposits or wanton and too rapid utilization of growing trees, may or may not be advisable as a conservation policy. Yet it is eminently proper for this association to acquaint itself with prevailing modes of taxing this peculiar class of property. We should certainly seek to correct existing inequities, and devise, if possible, improvements more nearly calculated to equate the tax burden of such interests with that borne by the general mass of persons, property and business, whence must come all public funds.

2. *Applicability of the ad valorem tax*

In the present confused situation over problems of public finance the clamor for new engines of taxation is more disconcerting than enlightening. Novel theories and plans include the separation of state and local taxes; extension of the inheritance tax, the franchise tax, and the income tax; the occupation tax; the severance tax; the sales or turnover tax, and the introduction of sundry excises, whose classification baffles both courts and doctrinaires. Each of these devices has certain merits and all, perhaps appropriate functions. Many, however, have never stood the test of time. Certainly none will be able to entirely supplant that "old stand-by"—the general property levy.

No revenue system has ever been so mercilessly condemned as the property tax, nor has any fiscal scheme been more sadly abused. Theoretically, the property tax is at once the simplest and most direct, and in view of the democratic structure of our civil polity, the most easily applied. Yet in practice, through a distorted idea of the magic of the uniformity principle it has been most woefully botched.

No scheme, if meritorious in its possibilities, however, should be rejected because patient effort is required in its fruition. The airplane and the telephone in their inception presented what both critics and laymen pronounced insuperable barriers; but by patience and persistent effort on the part of science, the iridescent dream of the '70s and the wild vagary of the later decade have become realities of today.

The property tax, though despised and berated for its hereditary faults, is destined yet to be the chief cornerstone of the future fiscal edifice. It behooves the membership of our organization, set apart as we are from a less discriminating public, to depart with reluctance from a system which, after all has been said against its past performance, holds yet a hope for the future not vouchsafed by any of its ambitious substitutes.

The shortcomings of the property tax arise for the most part from sources external and superficial. The chief cause of disappointment is due to the excessive commercial development of the community, which has often traveled far ahead of any legislative program. But, as will be later shown, a path is open whereby the ascertainment of value by the taxing power may be successfully attained on the same scientific basis long in vogue throughout the business world.

3. *A broad prospective necessary*

The taxation of natural products involves a thorough understanding of fundamental economic facts. When these are comprehended, the application of the *ad valorem* tax to such plainly taxable objects is facilitated by the use of modern aids familiar to every large-scale business man.

At the threshold of this discussion, let me impress the thought that in the treatment of natural resources, two aspects of value are presented—the actual and the potential—the present and the prospective. The virgin forests of Canada represent a large portion of the potential wealth of that dominion of the British Crown. Likewise the unexplored oil fields of Mexico, the nitrate deposits of Chile and the diamond mines of Kimberly and the neighboring gold fields of the Transvaal constitute respectively the illimitable heritage of those countries enriched by the munificent hand of God.

Natural resources, however, are not liquid, like commercial paper. They have no realizable value, except through the increase of population and the pressure of demand. Eventually the day comes, however, when purchasers, willing to pay a valuable consideration for these units of wealth, appear and cry their bids in civilization's stock exchange.

Commercial cupidity is gradually awakened *pari passu* with the march of human progress. Unless restrained by a far-visioned national policy, in obedience to the law of supply and demand, all natural resources inevitably gravitate into private ownership. Often the consideration paid for these basic units is a mere song, with no relation to the true potentialities of the properties transferred. As population increases natural resources are depleted often in geometrical progression. This process, of course, involves a certain and steady, though sometimes slow, enhancement of intrinsic worth.

4. *Enhancement through assembling of units—integration*

An incidental factor is the increased value gained through the mere act of assembling under one control originally separate units.

a. City property.—In populous centers an "unearned increment" follows the assembling of various small parcels of ground to compose a larger and strategic plot, of sufficient size to justify the erection of a single improvement of great and permanent worth. In cities the product of such assembling of tracts is called "plottage," and its enhanced value is recognized in the business world, as it should be in the taxation laboratory.

b. Timber lands. — In the development of timber lands, it is a well known fact that greater economies are secured by large operations. The larger sawmills seek sufficient accessible stumpage to justify the building of tramroads and other plant facilities for reducing the unit cost of manufacture .

c. *Mineral deposits.*—In the mining world, the first inquiry after the discovery of a promising deposit of ore, is as to the extent of the local occurrences. Exploration of adjoining territory, to ascertain the quantity as well as the quality of the deposit precedes a decision as to the commercial value of the prospective mine. The ton-unit is given only a tentative valuation until it can be ascertained whether the mineralized area is sufficiently extensive to justify capital expenditure adequate for its economical development. If so, each unit becomes for that reason alone of greater value, and is accordingly appraised and re-inventoried in the catalogue of commerce.

The famous decision of the interstate commerce commission in 1912 abrogated the unlawful practice of a division with proprietory lumber companies of transportation revenues. One hundred taplines owned by lumber companies of the southern pine territory had been receiving millions of dollars for service which the commission held to be that of mere plant facilities. It was said (p. 300):

> "While Mr. Foster, president of the tap-line, and also president of the lumber company by which it is owned, was testifying, it appeared that it was the desire to legalize the allowance that led to the incorporation of his tap-line to Landers, and the desire to monopolize the forests and thus control the timber that led the lumber company to retain the ownership of the logging road beyond." *The Tap-Line Case,* 33 I. C. R. 277.

The price paid for stumpage is almost always a measure only of the value placed upon it by the vendor, who if not in a position to operate it, may be willing to part with it for much less than its real value.

In buying from original owners operators rarely pay full prices, but almost invariably what they believe to be a small fractional part of the real value.

The larger or normal prices are obtained only by those vendors who are independent or who themselves are operators and know real values and are in position to realize them by development.

From the foregoing it appears that the market value of natural resources, such as a block of timber land, a million feet of stumpage, an oil lease in proven territory or a mining claim of ascertained extent, should be determined for purposes of taxation, with an eye to the real potential value under present or future ownership.

5. *Examples of enhancement through unearned increment*

It is an historic fact that enormous holdings of timber lands throughout the country have been assembled by speculators for considerations little less than gratuitous. Purchase from small farmers, non-residents and others, through options and intermediate contracts, before the true value of the products are known has been the rule, rather than the exception. For example, millions of acres of pine timber in Arkansas which were acquired a few years ago on the basis of from ten cents to twenty-five cents per thousand, for stumpage, would not now be sold for less than from five to ten dollars.

Moreover, after a given territory is sufficiently blanketed by the operator's holdings, his buying program usually stops, for the obvious reason that remaining stumpage tributary to the mill can, by waiting, be had at a price much less than its actual worth. Since it is left so scattered as to be desirable, from a manufacturing standpoint, by no competing interest, the market for the isolated tract is virtually destroyed.

It is a common practice, indeed, where two or more lumber companies enter a given timbered region, to immediately choke all competition by a division of territory among them, so that each operator may purchase at the mutually fixed maximum price for timber, knowing that it will not be exceeded by his friendly adversary. Thus there can be no clash of interest by reason of one company invading the other's territory.

The Aluminum Company of America, in twenty years, placed a hitherto unknown metal fourth in commercial rank. It has built up a dominant monopoly in its field, secure in its holdings of mineralized lands in Arkansas, affording a supply of bauxite for a half-century. This close corporation has managed to buy up or freeze out all competition, and has been enabled by adroit tactics to acquire, for less than a million dollars, a mining property whose book value today exceeds nine million dollars.

And yet, by the use of that fetich phrase "market value", in a primitive statute, written years before mineral development was foreseen, the law ignominiously falls down. It fails to anticipate the scientific phases of potential value which private exploration has later brought to light. *Am. Bauxite Co.* v. *Board of Equalization,* 119 Ark. 362; 117 S. W. 1151.

6. *Valuation should comprehend both present and prospective factors*

As stated by Prof. M. H. Hunter in the introduction to his recent "Outlines of Public Finance"

> "The march of progress in the development of government is from the simple to the complex, and the more complex the

> organization the more numerous and difficult are the problems which present themselves."

In casting about for intelligent guidance in the difficult task oi evaluating property, tax administrators may do well to heed the authoritative ruling of the supreme court of the United States.

In *Cleveland C. & St. L.* v. *Backus,* 154 U. S. 439, 445; 38 L. ed. 1041, 1046, Mr. Justice Brewer laid down this forceful formula:

> "The rule of property taxation is that the value of the propery is the basis of taxation. It does not mean a tax upon the earnings which the property makes, nor for the privilege of using the property, but rests solely upon the value. But the value of property results from the use to which it is put, and varies with the profitableness of that use, present and prospective, actual and anticipated." See also ***Monongahela Navigation*** *Co.* v. *U. S.,* 148 U. S. 312; 37 L. ed. 463 (value for condemnation).

7. *The public's right to technical service*

What has already been said indicates that the true or "market" value of mineral properties, and especially of those accumulations of natural resources which are hidden and underground, cannot be intelligently appraised by the untrained local assessor. Without special machinery or equipment for the scientific admeasurement of such secret values, they would remain undiscovered and sealed, so far as the public is concerned, and the real worth of this class of property, though well known in the industrial and commercial world, would never be reflected upon the tax books.

Yet such properties are freely bought and sold, hypothecated and transferred for a definite cash consideraion. Hence it is plain that some mode of reliable appraisement exists which is acceptable in financial and banking circles. It is for the employment of the same modes of evaluation, for the purpose of taxation, that economists and progressive statesmen are beginning to interpose a most earnest plea.

As aids in determinng the value "present and prospective" of basic material resources, the state should have at her beck and call the best talent of the scientific world. Two fields of modern research furnish the eyes whereby, with microscopic accuracy, technical values are identified in the marts of trade. These two eyes are the appraiser and the accountant. The appraiser's services are indispensable in ascertaining inventory values, while those of the accountant are equally necessary in interpreting books of account or the record of business transactions, and of profit and loss.

The disinterested auditor's and engineer's report, the balance-sheet, the appraisal, and the profit and loss account all are "bills of particulars," without which a valuer must grope in the dark—whether the conclusion sought is for purposes of condemnation, rate regulation, capitalization, taxation or for sale.

The state, in her sovereign role, is the author, creator and guarantor of property rights.. She is the mother-protector of all operations whereby natural resources are reduced to individual control. The state by her grace accords the usufruct. Should she not, in return for such invaluable support, be yielded her definite dues? Whether it be a share of the income from operations, or a rental charge for profitable forbearance to develop, the state should get hers first.

A well-organized appraisal company is equipped not only to cruise and value forest properties, but to appraise all classes of mining properties as well. They possess facilities for accurately evaluating both real estate devoted to such special uses and also the mining machinery, plant, tram-roads and operating facilities of any mill. They are, moreover, thoroughly capable of cruising and appraising undeveloped mineral deposits. In this respect, their working equipment is more adequate than that of the geologist, who is not usually prepared to place on property a commercial value.

The petroleum and natural gas industries with their infinite ramifications and marvelous expansion in recent years present the most intricate problem from the taxation standpoint. Special treatment is more imperative perhaps than in any other natural product. Yet a standard appraisal offers proven services in the disinterested investigation and valuation of every type of oil and gas property. embracing the equipment for refining, transportation, distribution and marketing of petroleum and its by-products.

The appraisal establishes values through a careful analysis of every influential factor, including the worth of the improvements, age of production, past production records, state of development of lease, location of property with reference to continued production, thickness and nature of oil-producing sands, probability of deeper sands in unexplored depth to which additional wells could be drilled and their probable cost, the cost of lifting oil, salvage value of equipment on exhausted leases, existing market conditions in the oil industry, etc.

Through its engineering department, such a company conducts a constant research in every phase of industry. Its personnel is presumably thoroughly trained and has developed practical experience; its reports have been approved and utilized by a large and satisfied but cautious clientele in the most conservative fields.

One of these companies has appraised upwards of 20,000 diversified commercial properties, public utilities, mineral and petroleum resources, during the last quarter of a century, and enjoys a prestige in banking and financial circles and among the investing public. In financing the purchase or sale of properties and in the formation of mergers the appraisal today is indispensable. It should certainly be of incalculable service to the public in the difficult and technical process of taxing natural resources upon an *ad valorem* basis.

By "appraised values" is meant a "valuation arrived at under the personal supervision of thoroughly qualified executives, whose skilled judgment is the result of many years' experience in valuation work, and who have the assistance of trained appraisers, using organized cost analysis records, statistical data, and being guided by checks of definite, predetermined and tested standards of valuation." An appraisal company is an executive organization, using established methods and records, which insures the testing of appraised valuations against well-established standards, and guarantees their uniformity and provability. The test of an appraisal organization is the extent to which it has reduced valuation work to an exact science.

Scientific valuations of mineral properties have been made by several of the more progressive mining states, and in every instance with enormous public gain. In Michigan the assessed valuation of the iron properties was increased pursuant to the appraisal of J. R. Finlay in 1911 from $27,000,000 to $85,000,000. And the 1921 assessment, in spite of the ten years depletion, due to new discoveries, reached the goodly total of $117,000,000.

The validity and effectiveness of a scientific appraisal is well illustrated by the experience of this state. In 1911 the board of tax commissioners, acting under authority of act No. 114 of 1911, employed Mr. Finlay, an expert mining engineer, to assist it in making an appraisal of mining properties. He was aided by Dr. C. K. Leith, Professor of Geology in the University of Wisconsin, and a corps of junior assistants. The total cost was less than $26,000.

The concrete result—the fruit of enlightened legislation, coupled with fearless administration by an efficient tax commission — is shown in the following table:

Counties	*Local assessment*	*Finlay's appraisal*	*As reviewed by tax commission*
Gogebic	$ 4,943,158	$ 41,560,000	$28,343,100
Dickinson	3,735,800	11,508,000	7,447,500
Iron	1,993,500	23,339,000	15,051,800
Marquette	8,951,050	42,734,000	34,800,000
	$19,623,508	$119,150,000	$85,642,500

The procedure, of course, was subjected to the acid test of judicial attack; but in the two test cases the assessments were fully sustained: *Sunday Lake Iron Co.* v. *Wakefield* (1915), 153 N. W. 14; *Newport Mining Co.* v. *Ironwood* (1915), 152 N. W. 1088.

In the Sunday Lake case the plaintiff's property had been assessed by an inexperienced local assessor who, "proceeding in entire good faith," adopted a value which his predecessor had placed upon the property—$65,000. The state board, in the light of the Finlay appraisal, raised the assessment to $1,071,000. The taxes were paid under protest, and the company promptly sued to recover what it termed the excess taxes for the current year, amounting to $31,910.45.

The supreme court of the state, in a unanimous decision, sustained the final assessment and affirmed the decision of the lower court which had approved and confirmed it.

On appeal to the United States Supreme Court, the cause was affirmed, that court holding against the iron company on the two points urged, viz: (1) that the failure of the board, because of alleged lack of time and inadequate information, to cause a general survey of all property, did not invalidate its action with respect to the Sunday Lake mine; and (2) that a mere error of judgment, if existing, did not support the claim of discrimination, since the good faith of the taxing officials is presumed. *Sunday Lake Iron Co.* v. *Township of Wakefield,* 247 U. S. 350; 62 L. ed. 54; 38 Sup. Ct. 495.

In the companion case of *Newport Mining Co.* v. *Ironwood,* the total actual real estate value of Gogebic County was $56,467,012, and the assessment by the local assessors of both real and personal property was only $12,829,605. Among the properties was that of the Newport mine, whose assessment was at $2,188,640, and was appraised by Mr. Finlay at $13,400,000. The value finally fixed by the commission was $8,535,000. Taxes based on this revision, in the sum of $98,996, were paid under protest, and the suit for recovery followed.

In an exhaustive opinion the court sustained the scientific valuation, notwithstanding the contention that the expert appraisal related only to the mining property, leaving untouched all other real estate and personal property of the county, urged as under assessed to an equal extent.

It was further held in this case that the state is not limited to the capitalized royalty received by the owner of mining property, since the royalties themselves may be undervalued and the property may be worth more than the owner received. Says the court (p. 1093):

> "It will be admitted that the availability and value of minerals, unmined, are not matters of common knowledge, nor to be correctly ascertained or estimated except by men possessed both of certain particular information and of expert knowledge."

And again, apropos of the principle we are emphasizing in this paper, the court continues (p. 1094):

> "There is no reasonable ground for contending that the state may not use the methods of business to ascertain such values. In such a case, it is not compelled to ignore, or discount, the facts of demonstrated availability, quantity, and quality of mineral. If a rule or method exists by which engineers and business men ascertain the values of ore bodies for the purpose of buying and selling them, if no better rule is or can be suggested, how can it be said that the rule is wrong in principle when adopted by the state? The state must, of necessity, treat the peculiar subject of taxation as the subject requires, not to change or modify a cardinal rule of taxation, but to apply it. Upon this record no other rule is suggested, and the rule employed is conceded to be the rule of engineers in like cases."

Time and space forbid mention of other astonishing tax values uncovered by scientific surveys from time to time in Minnesota, Wisconsin, Arizona, Utah, Pennsylvania, and recently in New Mexico.

It has wisely been pointed out:

> "A valuation reached by a scientific survey is fundamentally an analytical appraisal. Opinions are used only when carefully checked by actual sales and transfers of property in the industry. Because they are the result of analysis rather than estimate, *they are capable of proof*. An opinion is likely to be shaded by a number of factors; while an analysis is impersonal and is not subject to shading. Analytical appraisals are scientific, provable and precise, whereas many opinion valuations are merely the result of hit-or-miss guessing."

8. *The ideal system of taxation is a composite*

If final equality in taxation is ever to be achieved, according to Adam Smith's famous dictum, the means for attaining equality must be so elastic as to be adapted to changing conditions. In the march of civilization, taxation should keep abreast with progress.

With respect to natural resources as a taxable subject, two propositions are self-evident: (1) the steady increase of population, and (2) the steady depletion and final consumption of basic resources.

As the demand for satisfaction of human wants gathers momentum, the basic and non-reproducible means for such satisfaction, represented by what we now term natural resources, is gradually consumed and finally disappears. In this depleting process the quantity units automatically enhance in value in inverse ratio to the available supply. The scale of values thus registered in the market should be reflected also on the text books.

In the face of this inevitable situation then, is it not madness to continue the slipshod method of permitting the owners of these fast disappearing resources virtually to assess themselves. The formulation of any effective plan for the ascertainment of true values of private holdings of natural resources requires indeed much thought and patient investigation. This, however, should be no obstacle in the way of undertaking so vital and important a task. It does not discourage private initiative when these properties are passed upon for the purpose of mortgage or sale. The same procedure by which a scientific valuation is approximated in voluntary transactions should be available when the state annually claims her modicum of taxation.

It will not do to say that an income tax alone produces equality and justice in such cases, for even the income tax cannot be universally applied, without unequal results.

The ideal system of taxation is a composite structure, including the machinery of the property tax, where that is indispensable, and the more direct incidence of the income tax where that will better fit. In addition, various forms of business taxes which experience has proved to be efficacious invite investigation. In the treatment of such eminently appropriate subjects of taxation as minerals, building stone, forests, fisheries, water-sheds, and other natural resources, research should be broad and decision definite.

In view of the vital economic importance of these subjects, the general property tax now applicable thereto should not be given up. On the contrary, the system should be perfected in its ramifications, so that the true potential, as well as actual, presently-realizable, values, without regard to market considerations in the narrow sense, may be bared and a proper rate applied.

This recommendation is contained in substance in the special report of the committee on mines taxation, considered at the Salt Lake City conference in 1920, where it was said (Proc. 13th Conf.. p. 410):

> " Approved methods of determining mining values for taxation should not differ in principle from those used in ordinary commercial transactions, for whatever a property is worth commercially, it should also be worth for taxation."

To this concise dictum might be added the words of authority in *Adams Express Co.* v. *Ohio State Auditor,* 166 U. S. 185, 220:

> " Now, it is a cardinal rule which should never be forgotten that whatever property is worth for the purposes of income and sale it is also worth for purposes of taxation."

No clearer statement of the peculiarity of mining property has ever been made than that of Mr. Justice Pitney in the now famous case of *Stratton's Independence* v. *Howbert*, 231 U. S. 399; 58 L. ed. 285, where he said, at page 413:

> "The peculiar character of mining property is sufficiently obvious. Prior to development it may present to the naked eye a mere tract of land with barren surface, and of no practical value except for what may be found beneath. Then follow excavations, discovery, development, extraction of ores, resulting eventually, if the process be thorough, in the complete exhaustion of the mineral contents so far as they are worth removing. Theoretically, and according to the argument, the entire value of the mine, as ultimately developed, existed from the beginning. Practically, however, and from the commercial standpoint, the value—that is, the exchangeable or market value—depends upon different considerations. Beginning from little, when the existence, character and extent of the ore deposits are problematical, it may increase steadily or rapidly so long as discovery and development outrun depletion, and the wiping out of the value by the practical exhaustion of the mine may be deferred for a long term of years." [This case arose under the special excise tax act of Aug. 5, 1909, 36 Stat. L. 113-18.]

In denying the company's claim for a credit for the depletion of the mineral supply by the process of mining as an element to be considered in determining the factor of depreciation, the opinion continues (p. 415):

> "As to the alleged inequality of operation between mining corporations and others, it is of course true that the revenues derived from the working of mines result to some extent in the exhaustion of the capital. But the same is true of the earnings of the human brain and hand when unaided by capital, yet such earnings are commonly dealt with in legislation as income. So it may be said of many manufacturing corporations that are clearly subject to the act of 1909, especially of those that have to do with the production of patented articles; although it may be foretold from the beginning that the manufacture will be profitable only for a limited time, at the end of which the capital value of the plant must be subject to material depletion, the annual gains of such corporations are certainly to be taken as income for the purpose of measuring the amount of the tax."

9. *Typical modes of taxing mines*

Perhaps the best typical example of the special taxation of "natural resources" *eo nomine* is found in the severance tax of Louisiana. A provision in the constitution of that state, adopted in 1921, reads as follows (art. X, sec. 21):

> "Taxes may be levied on natural resources severed from the soil or water, to be paid proportionately by the owners thereof at the time of severance. Such natural resources may be classified for the purpose of taxation and such taxes predicated upon either the quantity or value of the product at the time and place where it is severed. No severance tax shall be levied by any parish or other local subdivision of the state.
>
> No further or additional tax or license shall be levied or imposed upon oil or gas leases or rights, nor shall any additional value be added to the assessment of land, by reason of the presence of oil or gas therein or their production therefrom."

At the date of the adoption of this article there had already been in uncontested operation in that state since 1916 successive severance tax laws, the latest being act No. 31, approved June 30, 1920, which levied a license tax "upon all persons, firms, corporations, or associations of persons engaged in the business of severing natural resources from the soil or water." So a proviso was incorporated into the constitutional article above quoted, reading as follows:

> "Provided, that until the Legislature shall have enacted laws carrying into effect the provisions of this section, all existing laws relating to severance taxes or licenses, and to the assessment and taxation of land producing oil or gas shall be and remain in full force and effect. Notwithstanding any legislative appropriation heretofore made or any allocation in this Constitution made, the Legislature shall allocate a portion of the severance tax on oil or gas not less than one-fifth of the amount collected therein to the parish from within which such tax is collected; provided, that the amount thus allocated shall not exceed two hundred thousand dollars ($200,000) to any parish in any one year.
>
> The Legislature shall provide for the distribution of the funds allocated to the parishes under this provision among the governing authorities having jurisdiction over the territory from within which such resources are severed and tax collected."

The legislature of 1922, after much debate thereupon, increased the rate on the production of oil from 2% to 3%, by act 140, effective Jan. 1, 1923. In the opinion of Joseph B. Elam, the president of the Mid-Continent Oil & Gas Association, of Louisiana, the new rate will require the industry to pay an additional $800,000 on its production, while the tax on all other natural resources remains the same. Hence there has been a storm of protest, and at present a suit is pending whereby the industry, in the words of Mr. Elam, proposes to "avail itself of those agencies of correction which the Constitution of the United States fortunately provides."

Also, according to Judge T. M. Milling, attorney for the Standard Oil Company of Louisiana, three per cent on the gross output of an oil well is in effect a gross income tax, and in many instances confiscation. He further maintains that such an exaction is in direct opposition to the theory that taxes should be in proportion to the benefits derived.

Since the Louisiana law and analogous statutes in Texas, Minnesota, Pennsylvania and other states impose this special license or occupation tax, in addition to the general property tax, the examples can hardly be said to afford a fair test of the desirability of the output exaction as a substitute for the *ad valorem* tax. The present occupation tax in Minnesota, approved April 11, 1921, since it superimposes upon the existing burden of *ad valorem* taxes a tax equal to six per cent of the valuation of all iron ores, operates so heavily upon the industry as to provoke resistance by the affected interests, now paying $18,000,000 annually in property taxes. The new law will add about $2,000,000. Hence it is that the final outcome of the pending test case (*Bennett Mining Co.* v. *Lord, et al.*, — Fed. —, decided May 24, 1922) will be looked upon with great interest, alike by the affected interests, students of taxation and the general public.

The Minnesota federal court, in the test case cited, sustained the law, holding that the mere mining of ore was a business, apart and independent from that of selling or transporting the product, and that as a business mining may lawfully be made the subject of an excise or occupation tax, citing *Stratton's Independence* v. *Howbert,* 231 U. S. 415; that the tax in question was an excise upon this business and not one upon the ore or the income from its sale, and that the method of determining the tax was not so inequitable as to render it obnoxious to the uniformity clause of the state constitution or violative of the Fourteenth Amendment, citing *American Mfg. Co.* v. *St. Louis,* 250 U. S. 459, 463.

Other states where special taxes upon the mining industry, additional to the general property tax, rather than in lieu thereof, and justified upon some legal theory or other, are the following:

The Texas gross receipts tax,
The Alabama tonnage tax,
The Pennsylvania output tax,
The West Virginia business ta

A review of the respective provisions of these various laws is impossible in this paper, but reference is made to an article by the writer in the *Bulletin* of the National Tax Association, May 1922, on "The Severance Tax". In perhaps every state where this tax exists, it is levied expressly upon or for the privilege of carrying on certain business transactions, and in the absence of the iron-clad shackles of property taxation, great disparity in the ultimate burden results.

One of the most interesting and elaborate opinions in the literature of this branch of the law is that handed down by the court of common pleas of Dauphin County, on Feb. 1, 1922, in the Pennsylvania case of *Heisler* v. *Thomas Colliery Co.*,[1] wherein the distinction between the businesses of mining anthracite and bituminous coal, as the basis for the legislative classification, is presented with great ability and convincing force.

The power of the state to distinguish, select and classify objects of taxation has a wide range of discretion, and in the Oklahoma test case on the gross production tax of that state the supreme court recognizes this legislative discretion, and asks the question (*In re Wolverine Oil Co.*, 154 Pac. 362, 367):

> "Is the present act, levying one rate of tax on oil and gas, and a lesser rate on ores bearing lead, zinc, jack, gold, silver, copper, or asphalt, and which omits a gross production tax on coal, in conflict with this rule? Clearly it is not. That mining property or the business of mining may be placed in a class by itself and taxed by some method peculiarly appropriate to that class is a valid exercise of a constitutional right on the part of the legislature, and needs the citation of no authorities in its support."

But the learned justice might have gone further and pointed out obvious characteristics, inherent in the mineral products selected, which afford sufficient bases for different treatment in the revenue law. For example, coal *in situ* is capable of comparatively easy admeasurement, and hence is better adapted than oil or gas to valuation under the general property tax system where it was permitted for practical convenience to remain. Likewise as to the ores of less frequent occurrence in Oklahoma and whose extraction is attended with greater hazard, a lower tax rate was applied, perhaps from considerations of a policy in taxation, which states may undoubtedly adopt.

The Kennedy bill, c. 148 of acts of 29th Leg., Tex. (1905) was construed by the court of civil appeals in 1907; *Producers' Oil Co.*

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[1] Affirmed by Pennsylvania supreme court, 118 Atl. 394, and by the United States Supreme Court, November 27, 1922.

v. *Stephens,* 44 Tex. Civ. Ap. 327; 99 S. W. 157. In defining the tax as an occupation rather than a property tax, the court said:

> "In our opinion, the tax is not upon the gross products of the oil wells, but upon the occupation of owning, controlling, or managing oil wells producing oil; and the amount of tax is measured by a percentage of the market value of the gross products. . . . It does not constitute double taxation, not permitted by the law, as it is within the authority of the Legislature to impose an *ad valorem* tax on the oil-producing property of appellants, and an occupation tax for the use of this property in the production of oil."

In this view the supreme court concurred, as evidenced by its refusal of a writ of error in that case, and by its express approval of the doctrine in deciding a few weeks later *Texas Co.* v. *Stephens,* 100 Tex. 628; 103 S. W. 481, wherein at page 629 it is said:

> "The taxes in the act are levied because the persons specified are engaged in particular, defined businesses, and are laid upon the carrying on of those businesses. . . . Had the statute simply defined the businesses and imposed a tax of a fixed sum upon each, no one would have questioned that it was a tax upon the doing of the businesses; in other words, an occupation tax. The fact that the amount of the tax is to be determined in prescribed methods from the value, or extent, or magnitude of the businesses done, cannot convert it into an *ad valorem* tax upon the property of the persons conducting them."

On appeal to the Supreme Court of the United States of a companion case, challenging the validity of the law, the decision of the state supreme court (*Southwestern Oil Co.* v. *State,* 100 Tex. 647; 103 S. W. 489) was duly affirmed by the United States Supreme Court. Mr. Justice Harlan, in the opinion (217 U. S. 114, 120; 54 L. ed. 688; 30 S. C. 496) said:

> "The tax in question is an occupation tax only. . . . The tax was imposed by the legislature, charged with the duty of providing the means necessary for the support of the state government. That branch of the state government alone could declare what taxes should be imposed and upon whom or upon what kinds of business imposed. . . .
>
> But it is contended that the statute contravenes the Fourteenth Amendment. . . . This position is based mainly on the ground that the statute by imposing a tax on *wholesale* dealers in coal oil, naphtha, benzine, mineral oils refined from petroleum . . . while omitting to put any such tax whatever on wholesale dealers in other articles of merchandise—such, for

> instance, as sugar, bacon, coal and iron — so discriminates against wholesale dealers in the several articles specified in § 9 as to deny them the equal protection of the laws."

The value of mining property, according to a mining engineer of repute,[2] is not to be estimated by the amount of the dividends it may be paying at any particular time, but by the number and present value of the dividends it may be able to pay in the future.

Dr. H. L. Smyth of the Harvard chair of mining and metallurgy, in American mining congress proceedings, 1913, p. 29, cites the Michigan experience as confirming the applicability of the general property tax. He says: "The fundamental trouble is the fact that the valuations of mining property made by local assessors are generally not made on any uniform basis and that these valuations cannot be equalized by the ordinary Boards of Equalization with the valuations of other forms of property in the state."

Professor Smyth goes on to speak of the long experience in Michigan with specific taxes on the mining industry, beginning as early as 1853 with a tonnage tax of ten cents on iron ore, reduced in 1872 to three cents and in 1873 to one cent, and abandoned altogether in 1891; saying:

> "We then went back to the *ad valorem* system with valuations made by the local assessor under the General Property Tax Law. Conditions are perhaps somewhat peculiar in Michigan because there is a great preponderance of mining property in the Upper Peninsula and of other forms of taxable property as well as of political power in the Lower Peninsula. This, together with exaggerated notions on the part of the ignorant as to the profits made in mining, inevitably led to the general belief that mining property was undervalued, and caused the Legislature in 1911 to give the State Board of Tax Commissioners authority to value all the mines of Michigan.
>
> "Acting for the Board, this valuation was made by Mr. Finlay of New York in the early summer of 1911. The principle and method of this valuation have provoked wide discussion. . . .
>
> "Mr. Finlay's principle was to capitalize the net profits expected on an annuity basis. He first determined the probable annual net profits and the probable life of the mine. Part of the annual net profits he treated as income. The capital sum which at five per cent would yield that income was the value of the mine. The division of the annual net profits into these two parts was made by a well-known algebraic procedure followed by actuaries in solving similar problems.

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[2] R. H. Stretch, *Prospecting, Locating and Valuing Mines*, 11th ed., 1909, p. 20.

> "In order to determine annual profits it is necessary to know the cost per ton, the selling price per ton, and the tonnage that will be annually produced. In order to know the life of the mine, it is also necessary to know the total tonnage that the mine will produce.
>
> "These four factors are more or less matters of fact which are capable of being more or less closely approximated from past experience or by physical examination in the case of each mine. In addition, there are two other factors in the Finlay valuation, namely the rates of interest and these were assumed.
>
> "The general result of the Finlay valuation was greatly to increase the valuations of the iron mines. . . . The main criticism of the Finlay valuation has been directed against his assumption that a reasonable return on a mining investment is 5%. It is hardly necessary to say that this figure is absurd. . . ."

The Michigan tax commission had taken some account of these criticisms, by making a general reduction of 10% and 5% from the Finlay total, also by raising the interest rate to 6%, but Prof. Smyth contends that the proper rate is not less than 10%. He adds in conclusion:

> "An experience of three years has, I think, convinced the operators of Michigan that with due care in the determination of the factors the Finlay method is well adapted to determining the value of iron mining property, and that it will give more equitable results, not only as between the mines themselves but as between them and other forms of property, than any other."

The great merit from their point of view is that it affords a satisfactory method of keeping the mines under the general property tax law. The alternative is the tonnage tax, and to that they seem unalterably opposed.

Mr. R. C. Allen, state geologist, Lansing, Mich., in the proceedings of the 17th annual session of the American Mining Congress, said (pp. 35 *et seq.*), in referring to the report of the Committee on Mine Taxation (pp. 27 to 33):

> "In Michigan the general property tax extends to mines, and we are required to assess mines on the full *ad valorem* value, which is defined in law as the exchange value or sale value. . . .
>
> "It has also resulted in a much better spirit between the mining interests and the rest of the people, because the publicity given to the methods of mine valuation has amounted to a campaign of education. To the farmer, for instance, has been brought some of the important facts concerning the min-

ing industry; these have carried conviction that the industrial difficulties in the mining communities are of the same order as those which prevail among the farmers; and with this interchange of ideas there has grown up something like an era of good feeling. . . .

"We do not believe that the *ad valorem* is a perfect tax, but it has more nearly met the conditions in Michigan than any other tax we have ever had, and we have had some experience with the specific tax. . . .

"Mines are valued for purposes of sale; they are valued as a basis for expenditure in plant installation; they are valued as a basis for marketing of stocks and bonds, and for other commercial purposes. In fact the chief business of a great many expert professional men in this country is the rendering of these valuations.

"These experts will admit that they are quite competent to go out and examine a property, no matter what state of development it is in, and advise the client as to its value for purposes of investment. Then why refuse to recommend such valuation for purposes of taxation?

"Now, gentlemen, let us lay hold of this fact—whatever a property is worth for commercial purpose it is also worth for purposes of taxation. That is the underlying principle of the *ad valorem* system of mine taxation. The valuation of a mine for taxation is merely the best possible estimate of what that property is worth in the market in the condition in which it is found on the day of the appraisal. . . ."

10. *Forests as natural resources*

Our rapidly diminishing forests afford a peculiar example of the necessity for scientific classification of natural resources as subjects of taxation. The field, as a source of public funds, has been even less explored than mining. When we consider that it takes from 30 to 50 or 100 years or more to grow a crop of merchantable trees, it does not seem appropriate to classify the slow maturing timber crop with agricultural crops, annually harvested.

Moreover, when we consider that many of the large timber stands at present held under private ownership are matured and virgin—the original bounty of nature and not the product of voluntary cultivation — the conviction is irresistible that the original owners of these virgin forests should be treated with at least no greater leniency from a taxation standpoint than is due those timber owners who have purchased such properties for value received at the current advanced market.

Lumbering comes next to agriculture among the basic industries of the United States. In 1917, according to an official report (No.

114) of the Forest Service of the United States department of agriculture, the industry was represented by an investment of nearly two and a half billion dollars and by the employment of nearly a million men.

According to that document, the most common industrial unit of the lumber industry combines the ownership of timber with logging and milling operations. On the other hand, vast areas of stumpage are owned by individuals or companies, whose economic function is limited largely to holding the raw material and selling it from time to time to loggers or manufacturers. Speculators in quantities of public timber cheaply acquired, and the push of sudden development have carried timber values very high; indeed to a point presenting abnormal conditions puzzling to a resident of New England or Pennsylvania, where forest properties have been relatively stable.

From the same official source (p. 16) we glean the following facts:

> "The tax burden varies greatly in different forest regions. In the South as a whole it has never been a serious factor. The yearly taxes on large southern pine holdings vary enormously but appear to average about 1.7 cents per thousand feet, or from three-tenths to five-tenths of 1 per cent of their value."

Compare this low ratio with the average tax of one to two per cent of true value paid on all property, and the under-assessment of timber, at one-fourth its real value, is readily shown. A hundred thousand dollars worth of timber stands on the tax books to yield $400; while the same value of other property in general pays $1600.

The report continues:

> "Timber land taxes in various California counties average about 5 mills per thousand feet. . . . The rate in the Inland Empire averages about 1.7 cents per thousand feet. These yearly levies are equivalent to from one-third to 1 per cent of the present value of timberlands."

And the report contains the following interesting conclusion, confirming our indictment against prevalent haphazard methods:

> "It is improbable that the general property tax system levies upon timberlands more than their just share of local revenue over any considerable forest areas. Unsuited by nature to this form of wealth, however, it tends toward heavier taxes than a sound forest industry can bear. Uncertainty as to the future extent of this burden is a menace to the stability of timber ownership."

Much has been said and written of late to show the peculiar character of forest property, as calling for special classification. If, it is pointed out, the uniform general property tax rate is applied upon standing timber at actual value, this annual burden of "taxes prepaid in advance of income may easily absorb from fifty to one hundred per cent of the stumpage value of the timber at the time of cutting."[3] This stage is assumed to be in the remote future, upon the arrival of the stand at the degree of maturity most favorable to its commercial utilization.

But, as graphically demonstrated by a monograph on "The Cost of Growing Timber," by the well-known authorities on lumber, R. S. Kellogg, and E. A. Ziegler, of the Pennsylvania state forest academy, published by the *American Lumberman,* Chicago, in 1911, annual taxes, at the assumed average rate of one per cent of actual value (which according to the government report, heretofore cited, is more than twice what the average forest pays), are a minor factor in the economic cost. Other items—land and stocking, administration and protection, and especially interest on the capital—make up from two-thirds to three-fourths of the final cost.

The problem to be solved, therefore, is practical rather than theoretical. The vast bulk of existing timber holdings are virgin or original growth, as against cultivated or reforested areas. The great plan needed, then, is one which will fit our fiscal formula to forest properties of enormous present value. The equivalent in other fields of industry enjoys no such quasi-exemptions as are proposed by advocates of special classification of natural resources of this species.

The property tax is an existing fact — a condition and not a theory. With the development of our multitudinous interests, a more elastic policy will doubtless be evolved, but in too hastily seizing altruistic principles for the benefit of posterity, we may overlook a more pressing duty toward society of today. To equate present burdens, to offset inequalities, which promote the unlawful gain of the few, is the social task of the hour.

The private ownership in many states of large bodies of matured timber, costing but little to produce, yet constituting taxable property, seems indeed a serious "obstacle", in the judgment of expert foresters, such as Dr. Herman H. Chapman, to the adoption of a long-sighted transitional program of reform which he so admirably sketched last year at the Bretton Woods conference. Truly, as this authority declares, "a gulf intervenes between the recognition of these general principles and their application in practice a gulf intervenes which has so far not been successfully bridged."

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[3] Prof. H. H. Chapman, in Proc. 14th conference National Tax Association, p. 39.

Exceptional instances are the general forest conservation law of Louisiana (Act No. 232 of 1920).

Revaluation is then desirable, whether forest properties are to remain *in statu quo* or to be subjected to new treatment. Automatic adjustment or merger of property tax and yield tax upon severance, allowing credit at that stage, for previous annual payments, through interest-bearing certificate of indebtedness, is a practical plan proposed by Mr. L. S. Murphy of the Forest Service.

We shall not be "out of the woods," speaking literally as well as metaphorically, until that ideal point is reached—a consummation unhappily as yet quite remote. In the meantime, while striving constantly for approved reform in procedure under constitutional amendment, due effort should be made toward uniformity under present conditions.

Commercial cruises, such as the government employs in the forest reserves and the state of Washington and Louisiana have found practicable and effective, may achieve the double benefit of smoothing out accumulated inequalities and paving the way for sound economic reform.

Conclusions

Our examination of systems now in vogue for the taxation of natural resources is far from exhaustive and satisfactory; but even a cursory review of the statutes and practices in the various sections of the country disclose certain elements of strength and many points of weakness.

Our tentative conclusions from the study are:

1. Natural resources, because of their ancient origin and social importance, are largely a common heritage of the race; and because they are a wasting, non-reproducible asset, their gradual depletion works an irreparable loss. Hence, in the ascertainment of the peculiar and often hidden values of this species of property, modern scientific research and assistance is requisite, and to that end the periodic appraisal of all privately owned natural resources by competent, expert and disinterested appraisers and engineers is earnestly recommended.
2. The *ad valorem* system, under a constitution permitting classification of subjects, while not wholly adequate in the case of many ores and precious stones and exceptional classes of natural deposits, is an indispensable feature of fair taxation of the major mining properties, such as coal, iron, copper, zinc and bauxite, and of all non-operating mines.
3. The *ad valorem* system, modified and varied to avoid the undue burdening of cultivated timber and reforestation projects, is also a desirable method of taxing virgin and matured timber or timbered lands.

4. The severance tax and kindred exactions is an unexcelled method for taxing developed oil and gas properties and mines engaged in the extraction of precious stones and ores not readily susceptible of admeasurement *in situ*, though it is doubtful whether it should ever be the exclusive tax. Aside from the classes here referred to, the severance or output tax, if employed at all, should be merely nominal and supplemental.

5. No severance tax, as a revenue measure, should be imposed from motives of conservation merely; but this worthy policy should be worked out through other legislative channels.

The Occupation Tax

Royalty Taxes

BEING CHAPTERS VI AND VII OF
THE NINTH BIENNIAL REPORT

OF THE

Minnesota Tax Commission

FROM
NATIONAL TAX ASSOCIATION,
OFFICE OF TREASURER.
195 BROADWAY. N. Y. CITY

1924
ST. PAUL, MINNESOTA

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CHAPTER VI

THE OCCUPATION TAX

State taxes are imposed on specified occupations and business activities in a number of states, particularly in the states embraced in the South Atlantic, and East and West South Central groups. They are frequently described as license or privilege taxes, a privilege being generally defined as the right to engage in a business or profession. They are usually imposed in addition to ad valorem taxes. In some cases they are apparently in the nature of regulative taxes or licenses, while in other cases the rates are sufficiently high to bring them within the class of revenue measures.

In some states these special imposts are known as business taxes. In a general way business taxes may be defined as taxes upon business or business activities exacted from persons, natural and corporate, by reason of the business in which they are engaged. The amount of the tax is frequently based on the volume of business done, but more frequently on the value of the thing produced, though sometimes a specific fee is exacted regardless of the volume or value of the business done.

Tennessee makes extended use of the occupation or business tax. In that state a tax or license is imposed annually on almost every line of business and professional activity, except agriculture and manufacturing. One hundred and five different lines of business activities are subject to special state taxes or licenses, while twenty-two professions or occupations are subject to special imposts annually.

Alabama is another state in which liberal use is made of occupation or business taxes. Special taxes or licenses are imposed annually on seventy different lines of business activities, and on twenty-five professions or occupations. Persons engaged in the occupation of mining iron ore pay a tax of 3 cents per ton, the tax being paid into the state treasury monthly. This tax is in addition to the ad valorem tax.

Louisiana also makes liberal use of occupation or business taxes, although not to such an extent as either Tennessee or Alabama. In that state thirty-four different lines of business activities and seventeen professions or occupations are subject to special taxes or licenses.

An interesting feature of the Louisiana tax system is its so-called "severance tax." Under a law passed in 1920, persons engaged in severing natural resources from the soil or water are subject to a license tax equal to 2 per cent of the gross value of timber, turpentine, and other forest products, sulphur, salt, coal, ores, marble, stone, gravel, sand, and other natural deposits, except oil and gas on which the severance tax is 3 per cent. The tax is in addition to the taxes imposed on real or personal property.

While occupation or business taxes are more widely used in the groups of states heretofore referred to, such taxes are also used to some extent in most other states. In a majority of the states, however, they are used as regulative taxes, rather than as revenue measures.

There has been a noticeable trend in recent years toward special taxation of natural resources, due in part no doubt to a widely prevailing opinion that the state should exact a relatively greater tribute from natural than from created wealth. In most cases the special exaction takes the form of a super tax, that is, it is imposed in addition to ad valorem taxes. The special tax is quite generally measured by gross market value, although in a few cases net or semi-net value is used.

As examples of this trend, reference may be made to the Arkansas severance tax of 2½ per cent imposed on the gross market value of minerals, ores, and certain other natural products; the Louisiana severance tax of 2 per cent and 3 per cent, already referred to; the tax of 5 cents per ton on coal, and the tax of 2 per cent of the gross value of petroleum or other mineral or crude oils in Montana; the tax of 1½ per cent of the market value of anthracite coal prepared for shipment in Pennsylvania; the tax of 2 per cent of the average market value of oil and sulphur in Texas, and finally, the occupation tax of 6 per cent of the value of ores mined in Minnesota during the year.

Special Taxation of Iron Ore in Minnesota

The earliest attempt in Minnesota to apply special taxation to iron ore dates back to 1881, almost three years before the first shipment of ore was made from the Vermilion Range. In that year a law was enacted imposing a specific tax of one cent per ton on all iron ore mined in the state, such tax being in lieu of all other taxes and assessments on mining property. This tax remained in force until 1897, when it was repealed, following an opinion by the attorney general that the law was unconstitutional. Thereafter, and up to 1914, iron ore was subject to the same rule of taxation as other property.

By chapter 483, Laws of 1913, effective January 1, 1914, property was divided into four classes for purposes of taxation, each class being subject to assessment and taxation at a different percentage of true and full value. Under this law iron ore, whether mined or unmined, constitutes Class 1, and is subject to taxation at 50 per cent of its true and full value. This was the highest percentage applied to any of the four classes, the other three classes being taxable at 25 per cent, 33⅓ per cent, and 40 per cent of full value, respectively. This law, so far as it applies to iron ore, is still in effect.

The application of special taxation to iron ore has engaged the attention of the legislature at almost every session since 1907. A bill was introduced in 1907, classifying mines as "A" and "B", the former being defined as mines having iron ore of a metallic content of 49 per cent or more, and the latter as mines having ore of less than 49 per cent in metallic content. Mines in class "A" were to be assessed and taxed for county and local purposes in the district in which the mine was located. No levy for state purposes was imposed on mines in this class, but in lieu thereof, a state tax of 5 cents per ton was imposed on the tonnage mined each year. The bill failed to become a law.

Under a bill introduced in the 1909 session of the legislature, mines producing 20,000 tons or more of ore between January 1, and September 1, of any year were designated as class "A", and all other mines and lands containing iron ore as class "B." Mines in class "A" were made subject to a specific tax on production, based on metallic content as follows:

Mines yielding less than 49 per cent in metallic iron, 2 cents per ton.

Mines yielding 49 per cent or over and less than 54 per cent, 3 cents per ton.

Mines yielding 54 per cent or over and less than 59 per cent, 4 cents per ton.

Mines yielding 59 per cent or over, 5 cents per ton.

The graduated tax on mines in class "A" was in lieu of all other state taxes, but such mines were subject to county and local taxes. Mines and mineral lands included in class "B" were to be assessed and taxed in like manner as other property in the same assessment district.

The bill passed both branches of the legislature but was vetoed by the governor.

Bills similar to the one considered in 1909 were introduced in both the sessions of 1911 and 1913, but failed to pass.

A new form of tonnage tax made its appearance in the session of 1917, under which a tax of 2 per cent was imposed on the gross value of ore at the mouth of the mine. The tax was to be in addition to all other taxes levied on mining property and was to be paid into the general revenue fund of the state. The bill failed to pass.

Five different bills affecting the taxation of iron ore were introduced in the regular session of 1919. All of them, with one exception, differed materially in principle from the bills theretofore introduced. The bills considered at other sessions based the tax either on the metallic content of the ore mined, or its gross value at the mouth of the mine, while the two bills that were finally considered at the 1919 session imposed the tax on either the net or semi-net value. All of the bills failed of passage.

In the extra session of 1919 a bill was introduced "providing for the levy and collection of a tax upon the value of ores from persons, co-partnerships, associations, joint stock companies and corporations engaged in the mining or production thereof" equal to 5 per cent of the value of all ores "produced and shipped" during the year. Provision was made for the deduction of certain specified mining and shipping costs. The bill passed both branches of the legislature but was vetoed by the governor at the close of the session. In its administrative features this bill was substantially the same as the one enacted into law in the session of 1921, though materially different in its application.

The Occupation Tax Law

The bill introduced in the 1921 session of the legislature differed from its predecessors of other sessions in at least one important particular—the tax imposed under it was definitely designated as an "occupation tax." The full text of the bill follows:

CHAPTER 223—H. F. No. 760.

An act providing for the imposition of a tax upon persons, co-partnerships, companies, joint stock companies, corporations, and associations however organized engaged in the business of mining or producing iron ore and other ores, for enforcing and collecting the same and prescribing penalties for the violation thereof.

Be it enacted by the Legislature of the State of Minnesota:

Section 1. **Occupation tax of 6 per cent on iron ore.**—Every person engaged in the business of mining or producing iron ore or other ores in this state shall pay to the state of Minnesota an occupation tax equal to 6 per cent of the valuation of all ores mined or produced, which said tax shall be in addition to all other taxes provided for by law, said tax to be due and payable from such person on May 1 of the year next succeeding the calendar year covered by the report thereupon to be filed as hereinafter provided.

Sec. 2. **Value of ore—How ascertained.**—The valuation of iron ore or other ores for the purposes of determining the amount of tax to be paid under the provisions of section 1 of this act shall be ascertained by subtracting from the value of such ore at the place where the same is brought to the surface of the earth, such value to be determined by the Minnesota tax commission:

1. The reasonable cost of separating the ore from the ore body, including the cost of hoisting, elevating, or conveying the same to the surface of the earth.

2. If the ore is taken from an open pit mine, an amount for each ton of ore mined or produced during the year equal to the cost of removing the overburden, divided by the number of tons of ore uncovered, the number of tons of ore uncovered in each such case to be determined by the Minnesota Tax Commission.

3. If the ore is taken from an underground mine, an amount for each ton of ore mined or produced during the year equal to the cost of sinking and constructing shafts and running drifts, divided by the number of tons of ore that can be advantageously taken out through such shafts and drifts, the number of tons of ore that can be advantageously taken out in each such case to be determined by the Minnesota Tax Commission.

4. The amount of royalties paid on the ore mined or produced during the year.

5. A percentage of the ad valorem taxes levied for said year against the realty in which the ore is deposited equal to the percentage that the tons mined or produced during such year bears to the total tonnage in the mine.

6. The amount or amounts of all the foregoing subtractions shall be ascertained and determined by the Minnesota Tax Commission.

Sec. 3. **Mining companies to report annually.**—Every person engaged in such mining or production of ores shall, on or before the first day of February, 1922, and annually thereafter on or before the first day of February of each year, file with said commission under oath a correct report in such form and containing such information as the tax commission may require, covering the preceding calendar year.

Sec. 4. **Tax commission to determine tax.**—Upon receipt by the Minnesota tax commission of such report it shall determine from such information as it may possess or obtain whether the same is correct or otherwise, and if found correct, said tax commission shall, on or before May 1, find and determine therefrom the amount of tax due from such person.

Sec. 5. **Same when report is incorrect.**—Upon receipt by the Minnesota tax commission of such report it shall determine from such information as it may possess or obtain whether the same is correct or otherwise, and if found incorrect, from such information as it may possess or obtain, it shall find and determine the amount of tax due from such person.

Sec. 6. **Procedure when no report is filed—Penalty for failure to report.**—If any person, subject to this act, shall fail to make the report provided for in section 3 hereof at the time and in the manner therein provided, the tax commission shall in such case, upon such information as it may possess or obtain, ascertain the kind and amount of ore mined or produced, together with the valuation thereof, and shall thereon find and determine the amount of the tax due from such person, and there shall be added thereto a penalty for failure to report, which penalty shall equal ten per cent of the tax imposed and shall be treated as a part thereof.

Sec. 7. **Determination by tax commission of amount of tax shall be prima facie evidence.**—Findings and determination by the Minnesota tax commission, as to the amount of taxes due under the provisions of this act, shall be in all courts, for all purposes, prima facie evidence of the facts therein stated.

Sec. 8. **Tax commission shall certify amount of tax to state auditor.**—The Minnesota tax commission shall enter on its records the amount of taxes found and determined by it to be due from any person, as herein provided, and on or before May 1 shall certify such amount to the state auditor; who thereupon shall make his draft upon such person for the amount of taxes as thus certified, and place the same in the hands of the state treasurer for collection.

Sec. 9. **Due before June 1st each year—Penalties for non-payment.**—In case the tax herein provided for is not paid before the first day of June of the year when due and payable, a penalty of ten per cent thereof shall immediately accrue, and thereafter one per cent per month shall be added to such tax and penalty while such tax remains unpaid.

Sec. 10. **State auditor's draft prima facie evidence of amount due.**—The draft of the state auditor for the tax or tax and penalties imposed by the foregoing provisions of this act shall be prima facie evidence in any court where proceedings may be brought for its enforcement that the amount therein stated is due the state from the person against whom the same is drawn.

Sec. 11. **Attorney general to collect unpaid drafts.**—On July 1 of each year the state treasurer shall deliver to the attorney general all unpaid drafts for taxes imposed under this act, and it shall be the duty of the attorney general to bring an action thereon in the district court of Ramsey County, or of the county where such ores are mined or produced, for the amount of such draft, together with interest, penalties and costs. The judgment of the court when so obtained shall bear interest at the rate of one per cent per month and be enforceable in the manner provided by law for the enforcement of judgment obtained in civil actions.

Sec. 12. **Penalty for false return.**—Any person who for the purpose of evading the payment of the tax hereinbefore provided, or any part thereof, makes any false return or report under section 3 hereof, shall pay to the state a penalty of fifty per cent of the amount of said tax; and any one who shall knowingly make or sign under oath any false return of the kind and amount of ores produced therefrom, and of the value thereof, or who shall knowingly submit any other false information required by this act, shall be deemed guilty of perjury, and upon conviction thereof shall be punished therefor as provided by law.

Sec. 13. **Records of companies to be open to inspection.**—All books, waybills, inventories, correspondence and memoranda relating to or used in the transaction of the business of any person owning or operating any such mine or mines, shall on demand by the Minnesota tax commission or its authorized representatives, be open to its inspection or examination. If any one having charge, control or possession of said papers and books of such person shall neglect or refuse on demand of the said tax commission or its authorized representatives access to the papers and books aforesaid, he or they shall be deemed guilty of a gross misdemeanor, and upon conviction thereof shall be punished therefor as provided by law.

Sec. 14. **Occupation taxes to be apportioned.**—All occupation taxes which shall become due and payable on May 1, 1924, and subsequent thereto, from persons, co-partnerships, companies, joint stock companies, corporations and associations however or for whatever purpose organized, engaged in the business of mining or producing iron ore or other ores, when collected shall be apportioned and distributed in accordance with Section 1 A, of Article 9 of the Constitution of this state in the manner following, to-wit: fifty per cent to the State General Revenue Fund, forty per cent to the Permanent School Fund and ten per cent to the Permanent University Fund. (C. 402, Laws 1923, supersedes Sec. 14, C. 223, Laws 1921.)

Sec. 15. **Unconstitutionality of one section not to affect others.**—Should the courts declare any section or provision of this act unconstitutional or unauthorized or in conflict with any other section or provisions of this act, then such decision shall affect only the section or provision declared to be unconstitutional or unauthorized and shall not affect any other section or part of this act.

Sec. 16. **Definitions.**—For all purposes of this act the word "person" shall be construed to include individuals, co-partnerships, companies, joint stock companies, corporations, and all associations however and for whatever purpose organized.

Sec. 17. This act shall take effect and be in force from and after its passage.

Approved April 11, 1921.

Commission Restrained from Enforcing the Law

The so-called occupation tax law (chapter 223, Laws of 1921) imposing a 6 per cent tax on the business of mining iron or other ores in this state was signed by the governor and became a law April 11, 1921. The administrative features of the law, however, did not become operative until January, 1922.

In January, 1922, shortly after the tax commission had called upon mining companies for detailed reports of their mining operations for the year 1921, certain mining corporations obtained a restraining order from the federal court, enjoining the commission and certain other state officials from enforcing the law. The order which was dated January 26, 1922, was directed to each of the three members of the tax commission, the attorney general, the state auditor, and the state treasurer, and read as follows:

> IT IS ORDERED that a temporary restraining order be and the same is hereby granted and that the defendants and each of them, either as individuals or as representatives of the State of Minnesota be, and they are hereby enjoined, restrained and prohibited, until the hearing and determination of said motion for an interlocutory injunction and until the further order of the Court herein, from acting under or in pursuance of or from in any way carrying out or enforcing the provisions of the Act of the Legislature of the State of Minnesota, being chapter 223, of the Laws of Minne-

sota for 1921 and entitled "An Act providing for the imposition of a tax upon persons, copartnerships, companies, joint stock companies, corporations and associations however organized, engaged in the business of mining or producing iron ore and other ores, for enforcing and collecting the same, and prescribing penalties for the violation thereof."

It will be noticed that the restraining order was sweeping and rigid in its provisions. It was not directed alone against the computation of the tax, nor against its collection, for the amount of the tax had not been ascertained at that time, but against the enforcement of any of the provisions of the law, or even taking the preliminary steps leading up to the determination of the tax. Its plain purpose was to put the law in abeyance until its legality was tested and finally passed on by the court. In effect it was a suspension of the law, and during its pendency neither the tax commission nor any other official named in the order could enforce a single one of its provisions. Even had the amount of the tax been ascertained prior to the issuing of the order, no mining company could have paid its tax, no matter how desirous of doing so, for the state treasurer could not have accepted payment while the restraining order was in effect.

The issues raised were promptly heard in the United States district court, the mining companies joining the state in bringing on a speedy hearing. The lower court found against the mining companies in an opinion rendered May 24, 1922, the court holding that the mining of ore was a business, apart and independent from selling or transporting the product, and that the business of mining may lawfully be made the subject of an excise or occupation tax, citing *Stratton's Independence v. Howbert,* 231 U. S. 415; that the tax in question was an excise upon this business and not upon the ore or the income from its sale, and that the method of determining the tax was not so inequitable as to render it obnoxious to the uniformity clause of the state constitution or violative of the fourteenth amendment to the federal constitution.

An appeal was immediately taken to the United States supreme court by the mining companies. The case was argued on December 6 and 7, 1922, and on May 7, 1923, the supreme court handed down an opinion affirming the findings of the lower court, the mandate releasing the tax commission from the restraining order being filed June 26, 1923. For the full text of the opinion, see Oliver Iron Mining Company v. Lord, 262, U. S. 172. That the constitutional questions presented were difficult and important is evidenced by the fact that the supreme court held the case under consideration for more than six months before it handed down an opinion.

Reports from Mining Companies

On the same day that the mandate was filed releasing the tax commission and other state officials from the restraining order, blank report forms were mailed to mining companies, calling upon them for specific information relating to their mining operations for the year 1922, similar blanks for 1921 having been sent out prior to the issuing of the restraining order.

Most of the mining companies filed their reports as soon as the complicated and detailed information required could be compiled. It is only fair to say that practically all of the mining companies expressed their willingness to furnish the commission with any other information desired in addition to that called for in the report forms that might be required by it in determining the amount of taxes due the state. The commission availed itself of this offer as to some items of mining costs. With two or three exceptions, the mining companies were absolutely frank and open in every inquiry relating to their mining operations for both the years 1921 and 1922, and furnished the commission with much additional information that greatly aided it in properly computing the tax.

It was not an easy task to equitably and fairly solve the many doubtful questions that arose in the determination of the amount of the tax. The administration of the law is far from simple. It is complicated and indefinite in some of its provisions. In construing the law, however, the commission resolved every reasonable doubt in favor of the state. As a result, there was a wide difference of opinion between the commission and the mining companies as to the amount of tax due under the law, but the commission persisted in its own construction of the law and certified the taxes on that basis.

The following comparisons show how wide the difference was between the figures of the mining companies and those finally fixed by the tax commission. For 1921 the mining companies reported gross values at Lake Erie points of the ore mined in that year at $94,616,450; the commission fixed gross values at $99,799,747, a difference of $5,183,297. The mining companies reported the total cost of all operations, including overhead expenses and taxes, at $75,522,837; the commission allowed $62,494,285 in deductions, a difference of $13,028,552. Under the reports of the mining companies the net taxable value of the ore mined in 1921 was $19,093,613, with a total tax of $1,145,616; the commission fixed the net taxable value at $37,305,462, with a total tax of $2,238,327, a difference of $18,211,849 in net taxable value and $1,092,711 in amount of taxes.

The difference between the figures of the mining companies and the tax commission for 1922 was even greater than in 1921. The gross values of mining companies for that year amounted to $136,708,557; the commission computed gross values at $149,344,704, a difference of $12,636,147. The mining companies reported a total cost of $110,425,412; the commission allowed $92,001,412 in deductions, a difference of $18,424,000. Under the mining companies' reports the net taxable value of the ore was $26,283,145, with a tax of $1,576,989; the commission fixed the net taxable value at $57,343,292, with a total tax of $3,440,597, a difference in net taxable value of $31,060,147 and $1,863,608 in amount of taxes.

The total difference for the two years in the figures of net taxable values of mining companies and the tax commission amounted to $49,271,996, with a difference in taxes of $2,956,319.

Petitions for Reductions in Occupation Taxes and Abatement of Penalties

Shortly after the taxes were certified to the state auditor and state treasurer, the mining companies filed petitions with the commission requesting reductions in taxable values of more than $10,000,000 and aggregating more than $600,000 in taxes. They also asked for the abatement of penalties attempted to be imposed under the law. The principal allegations of the petitioners were that the published Lake Erie base values, which had been used by the commission, were higher than the actual prices for which the ore sold; that large quantities of ore were sold on long time contracts at much less than the published market price, and payments made therefor in monthly installments extending over the twelve months' period; that no allowance had been made for excess silica which reduces the value of ore; that proper allowance had not been made for depreciation of plant and equipment; that a loss on one mine had not been offset against the profit of another mine operated by the same company; that no allowance had been made for actual commissions paid for selling the ore, for cargo analysis, or for personal property taxes paid on stockpiles and movable mine equipment assessed as personal property; that penalties could not be imposed under the law and decisions of the courts until the amount of the tax had been ascertained and an opportunity to pay the same given the taxpayer. It was while the courts had the case under consideration that all of the penalties for failure to report or to pay the tax, accrued. The evidence presented to the commission shows conclusively that the contesting companies did nothing to delay the litigation, but, on the contrary, aided in every legitimate way to secure a prompt decision.

Two general hearings were held covering the matters complained of in the different petitions. After a full discussion and careful consideration of the allegations, the commission denied the requests for reduction in taxes, except in the case of six companies, in which small reductions were made to correct manifest errors in the reports of the companies or in the computation of the tax. The commission, however, did abate the penalties and substituted therefor an interest charge at the legal rate of 6 per cent per annum from the time the taxes were due until the same were paid.

Some criticism has been directed against the commission because of the abatement of penalties and the substitution of an interest charge of 6 per cent therefor. Most of the criticism, however, has come from people who were either unfamiliar with the facts or uninformed as to court decisions in similar cases. The commission gave the question of penalties long and careful consideration, and after an exhaustive examination of court decisions, it arrived at the conclusion that under existing circumstances penalties could not be enforced in the courts. However, exercising the powers of a court of equity vested in it in such matters, it determined that in equity mining companies should pay interest at legal rates covering the entire time payment of the taxes had been withheld. The following recital of the facts connected with the law, and the reasons upon which the final action of the commission as to penalties was based, may aid in a clearer understanding of the situation.

The classified assessment law, section 1989, General Statutes 1913, provides that iron ore shall be assessed at 50 per cent of its true and full value; city and village real estate at 40 per cent of its true and full value, and farm lands at 33⅓ per cent of their true and full value. Thus iron ore is assessed 25 per cent higher than city and village real estate and 50 per cent higher than farm lands. Because of this discrimination, and for other reasons set forth in their complaints, the mining companies claimed that the imposition of an occupation tax in addition to an ad valorem tax, already upon a basis much higher than was imposed upon any other class of property, was both unjust and unconstitutional, and in this belief carried the matter to the courts. This law involved a new and radical departure from existing methods of taxation and there was nothing unwarranted or reprehensible in appealing to the courts. It was the natural and logical thing to do, and was expected by everybody acquainted with the matter. It is fair to presume that if an occupation tax in addition to the ad valorem tax had been imposed upon the business of farming, the farmers of the state would have felt warranted in taking the matter to the courts before submitting to it, and no one could have rightfully blamed them.

Section 3 of the occupation tax law provides that the mining companies shall furnish the tax commission with correct reports in such form, and containing such information as the commission may require concerning the preceding calendar year, and from these reports, and from such other information as the commission may have or obtain, it is the duty of the commission to determine the value of the ore at the mouth of each mine and from the value so determined, to calculate the amount of taxes due from each company. A failure on the part of any company to make the report on or before February 1 in each year, if called upon by the commission to do so, entails a penalty of 10 per cent of the tax determined to be due from the offending company. But with the hands of the commssion tied by the court it was impossible in 1922 for it to call for these reports and therefore impossible for the mining companies to make them. Can it be possible that any court would exact penalties under such circumstances, or if it did, that any appellate court would sustain its decision? Such a decision would be a travesty on justice.

The law also provides that in case the tax is not paid by June 1 in the year when due and payable, an additional penalty of 10 per cent shall be assessed and thereafter one per cent per month shall be added until the tax is paid. But because of the order of the court, the tax commission was unable to determine the amount of taxes due, or to certify them to the state auditor until after June 1, 1923, and after all of the penalties had accrued, and it was of course impossible for any of the mining companies to pay until the amount of their tax was determined and certified. To add a penalty under such circumstances would be to penalize a taxpayer for failure to do an impossible thing, and it is inconceivable that any court would uphold penalties imposed under such circumstances. Such a decision would be so palpably unjust as to shock the moral sense of all fair-minded men.

It has been said that the tax commission should have left the decision of these matters to the court. But such statement is probably made in ignorance of the fact that the legislature has made the tax commission a court to determine just such questions. Section 1978, General Statutes of 1913, provides, among other things, that the tax commission "Shall hear and determine all matters of grievance relating to taxation;" and the supreme court has held that this statute means exactly what it says and that in matters of this kind its jurisdiction is even greater than any of the courts. Failure on the part of the tax commission to act on the merits of the abatement applications would have been a clear case of shirking its duties and responsibilities, and this it has never done. If the mining companies in this case did not present a fair showing that justice and equity required an abatement of penalties it would be hard to imagine such a case. The commission believes that the same kind of justice should be meted out to a mining company that is accorded to a farmer or a merchant, or to any other taxpayer. But however this may be, if these matters had been considered by the commission from the narrow legal standpoint alone, and without any reference to the questions of equity and justice involved, the result would have been the same. The great weight of judicial opinion in both state and federal courts is against the imposition of penalties in cases similar to this, and the courts of last resort abound in decisions holding that the attempt to impose penalties under such circumstances is illegal and void.

With little, if any, chance, therefore, of upholding the penalties provided in the law under the circumstances existing in these cases the commission decided, nevertheless, that it would by its order compel the companies, as a condition to the allowance of any part of their petitions, to pay interest to the state at the rate of six per cent from the time the tax was due and payable until the same was paid; and in case of failure or refusal to comply with this order, that their applications should stand as rejected. The commission felt that inasmuch as the state had been deprived of the use of the money due in taxes while the mining companies had had the use of it, that it was only equitable and just that they should pay interest at the current legal rate. By this decision the state lost nothing, and the mining companies gained nothing by the delay due to the suits. No other court would have been authorized by law to make such an order, and if the matter were taken to another court and the penalties held to be unlawful, it could not have exacted interest as the commission did. It is as sure as anything unprovable can be that no company would have paid penalties under the circumstances existing in this case unless compelled to do so by the court of last resort, while on the other hand the payment of interest was practically assured, for no company could afford to contest an order requiring such payment because it is so manifestly just.

There is still another phase of the situation that should be kept in mind in connection with the settlement and payment of the taxes on the basis of the tax commission's findings. As already stated, every reasonable doubt was resolved in favor of the state in computing the tax. This policy resulted in greatly increasing the amount of the tax over the figures submitted by mining companies. If, in addition to this increased amount, the commission had attempted to impose penalties, long and expensive litigation of doubtful outcome would have resulted. It is almost inconceivable to think that in computing a tax of several million dollars that was necessarily based as a starting point on arbitrary values, and involving the exclusion or inclusion of certain expenses incurred by mining companies in the mining, transporting and marketing of the ore, or in its construction of the phrase in section 2 of the law "the reasonable cost of separating the ore from the ore body," the commission had made no errors. The inclusion by the courts of any item of mining cost that had been excluded by the commission would not only have resulted in a reduction in the amount of the tax, but would have relieved the contesting companies of all penalties and interest for failure to pay, while at the same time, the state would not only have lost the interest, but would have been deprived of the use of the money for an indefinite period while the litigation was pending.

But regardless of this possibility, the commission felt that in view of the many court decisions holding penalties in such cases to be illegal and unenforcible, the state would be the gainer by several hundred thousand dollars by accepting the original tax with interest at 6 per cent. Forty of the forty-three companies subject to the tax at once complied with the commission's findings, and thus the state treasury was immediately enriched more than $5,500,000 by payment of the amount of tax so fixed by the commission, with an immediate additional payment of approximately $275,000 in interest charges, and this, too, at a time when there was pressing need for the money.

These are the reasons in brief that prompted the tax commission to abate the penalties. It has no apologies to make for its conclusions. It believes they were both legally and morally sound. It believes that every legitimate and equitable interest of the state was fully protected, and that by its findings, the state received more money than it would have received at the end of prolonged and expensive litigation.

The Computation of the Tax

As already stated in an earlier part of this chapter, the administration of the so-called occupation tax law is far from simple. Among other things, the law provides that the tax shall be measured by the value of the ore at the place where it is brought to the surface of the earth, less certain specified deductions. But in trade practice there is no recognized market value of ore at the mouth of the mine, nearly all iron ore being sold for delivery at Lake Erie points. It was therefore necessary for the tax commission to follow the ore to the place of its principal sale, and there ascertain its market value, and then work back to the mouth of the mine to determine its value "at the place where it was brought to the surface of the earth." To carry out this plan, the commission adopted as basic values what is known in trade practice as the Lake Erie base prices of standard ores, fixed annually, usually by early spring sales of ore, and generally regarded by the trade as being fairly representative of actual market values.

Having adopted Lake Erie published prices as basic values for the computation of the tax, the commission prepared and mailed to each mining company blank forms upon which to make verified reports, setting out in detail, among other things, the cost of developing the ore body, showing the development cost of open pit and underground mines separately, the tonnage made available for shipment by development work, the quantity and grade of ore mined each year, the cost of mining, beneficiating, and shipping the ore to the place of sale, its market value at Lake Erie points, together with much other detailed information which seemed necessary for the proper determination of development, mining and shipping costs, as well as the valuation of the ore mined during the year.

These reports were carefully examined and compared, and, in many cases, checked with information previously compiled by the commission. Where unusually high development or mining costs were shown, additional information, either by letter or personal conference, was required from the reporting company. Many claims for the inclusion of certain expenses in the amount deducted from the selling value of the ore were disallowed, because in the opinion of the commission, they were not of a character that brought them within the purview of the law. In every case of reasonable doubt they were excluded from deductions. While some of them were close to the border line, it is felt that in excluding them, the commission was correctly interpreting the intent of the legislature as expressed in the law itself.

The Tax Yield

The tax as finally computed and certified by the tax commission was considerably larger than the anticipated yield when the law was enacted. This was due in part at least to the policy of the commission of construing every reasonable doubt in favor of the state in computing the amount of the tax. For the year 1921 the tax certified to the state auditor and state treasurer amounted to the sum of $2,238,327.73; for 1922 to $3,440,597.54, and for 1923 to $6,126,443.18, a total for the three years of $11,805,368.45.

Perhaps it should be noted that mining activity was unusually quiet in 1921, only 17,253,970 tons being mined subject to the tax in that year. This was the smallest tonnage mined in any single year since 1904. There was a considerable increase in mining activity in 1922, the tonnage mined in that year being 28,606,530 tons. In 1923 the tonnage mined increased to 44,637,657 tons, the largest quantity mined in any single year, except in the years 1916 and 1917. While the tonnage mined in 1924 has not yet been reported, it will probably not exceed the tonnage mined in 1922.

Statement Showing Quantity of Ore Mined, Gross Value of Same, Amount of Deductions for Mining and Shipping Costs, Net Taxable Value, and Taxes for Each of the Years 1921, 1922 and 1923.

	1921.	1922.	1923.
Tons mined subject to tax	17,253,970	28,606,530	44,637,657
Gross value Lake Erie points	$99,799,747.45	$149,334,695.23	$250,339,623.95
Transportation costs.....	35,032,634.77	50,944,792.88	85,952,732.95
Value at mouth of mine..	64,767,112.68	98,389,902.35	164,386,891.00
Statutory Deductions:			
Development costs.....	3,566,720.63	7,064,587.70	10,996,555.88
Mining costs...........	15,380,845.46	19,780,076.72	32,042,383.91
Royalties	8,178,803.87	13,673,922.90	18,375.618.41
Ad valorem taxes......	335,280.56	528,022.36	864,944.76
Total statutory deductions	27,461,650.52	41,046,609.68	62,279,502.96
Net taxable value of ore.	37,305,462.16	57,343,292.67	102,107,388.04
Taxes at 6 per cent......	2,238,327.73	3,440,597.54	6,126,443.18

Statement Showing Averages Per Ton of Ore Values and Mining and Other Costs for the years 1921, 1922 and 1923.

Per Ton	1921.	1922.	1923.
Gross value Lake Erie points	$5.784	$5.220	$5.608
Transportation costs	2.030	1.781	1.926
Value at mouth of mine	3.754	3.439	3.682
Statutory Deductions:			
Development costs	.207	.247	.246
Mining costs	.892	.691	.718
Royalties	.474	.478	.412
Ad valorem taxes	.019	.018	.019
Total statutory deductions	1.592	1.434	1.395
Net taxable value	2.162	2.005	2.287
Average occupation tax	.130	.120	.137

The Tax Burden Measured by the Ore Mined

In any consideration of the fairness of the rate of taxation imposed under the occupation tax law, it should be borne in mind that this is a super or extra tax, as mining property is also subject to the general ad valorem tax, iron ore being taxable at 50 per cent of its full value. Then, too, it should also be remembered that the occupation tax is not measured by the net value of the ore mined, but on a percentage of net value. Based on the expense reports of mining companies, the deductions allowed represent approximately 83 per cent of total expenses, exclusive of interest on investment or depletion of capital. This would make the tax of 6 per cent imposed on partial net value equivalent to a tax of nearly 7¼ per cent on net value.

In 1921 the total of ad valorem taxes, state and local, imposed on mining property amounted to $18,185,156. If to this should be added the occupation tax of $2,238,327, we get a total tax obligation for that year of $20,423,483. This would be equivalent to an average tax of $1.18 on each ton of ore mined in that year, and would represent a tax equal to 54½ per cent of net value for occupation tax purposes, and 65¾ per cent of actual net value of the ore mined.

In 1922 the ad valorem taxes amounted to $18,411,500, and occupation taxes to $3,440,597, a total of $21,852,097. This is equivalent to an average tax of 76½ cents per ton of ore mined in that year, and represents a tax equal to 38 per cent of occupational tax value, and 46 per cent of net value.

In 1923 ad valorem taxes were $19,655,268, occupation taxes $6,126,443, and royalty taxes $1,007,085, a total of $26,788,796, which would be equal to an average tax of a little over 60 cents on each ton of ore mined in that year or.26¼ per cent of occupational tax value, and 31½ per cent of net value.

It will be noted from the above computations that the tax per ton decreases as the tonnage mined increases. This is largely due to the fact that in these computations all taxes are charged to the tonnage mined, and of course as the tonnage mined increases the average tax per ton decreases because of the larger tonnage over which the tax is spread. The computations show quite conclusively that the mining industry is not lightly taxed in this state.

Examination of Books of Mining Companies

While the tax commission has no reason to think that the reports made to it by mining companies were intentionally inaccurate or misleading, nevertheless it felt that such reports should be carefully checked and verified by an examination of the books of each mining company, with particular scrutiny of the items charged to development and mining costs, to see that no items of expense not fairly a part of deductible costs had been included in deductions from the value of the ore at the mouth of the mine. For this purpose it has for the past few weeks had a corps of accountants checking the books of the respective mining companies, and hopes to continue the work until the books of all operating companies have been checked and the reports duly verified. This work is being done by the regular office force of the commission, with the assistance of one additional employe.

Suggested Changes in the Law

While the commission has endeavored, as nearly as it could, to interpret the occupation tax law in the spirit of its authors, it fully realizes that in some of its provisions the intent of the law is capable of more than one construction. When any provision of a tax law is open to more than one construction, it not only leads to continual dispute between the taxpayer and the state, but not infrequently to expensive litigation. This situation should be avoided whenever possible.

It would greatly simplify the administration of the law if the base value upon which the tax was to be computed was definitely fixed in the law. This could be done by fixing the base value of ore for purposes of taxation at a definite amount for each unit of iron contained in the ore, due allowance being made for certain other elements in the ore that affect selling values.

In order that the tax may continue to be fairly uniform, measured by the net or semi-net value of the ore mined, the present statutory deductions should be continued, except that some of the present deduction provisions covering the cost of developing the ore body, as well as the cost of mining the ore, should be clarified and made more definite. For instance, the phrase in Section 2 of the present law, "the reasonable cost of separating the ore from the ore body" as an item of deduction may mean only the labor costs of such separation, or it may mean labor costs and all overhead outlays, including salaries and expenses of officers, engineers, and superintendents, regardless of where such officials may function. This provision should be amended and the items to be included in such expense definitely stated.

It is the purpose of the tax commission to prepare and present to the legislature for its consideration at the forthcoming session, a bill embodying the foregoing and certain other proposed amendments to the present statute in the interest of clarity and definiteness in the application of the law, and for the further purpose of avoiding, so far as reasonably possible, future litigation arising from different constructions placed on the same provision of law.

CHAPTER VII

ROYALTY TAXES

Complement to Occupation Tax

Chapter 226, Laws of 1923, known as the "Royalty Tax Law," the full text of which will be found at page 24 of this report, was enacted as a complement to chapter 223, Laws of 1921, known as the "Occupation Tax Law."* A bill providing for a royalty tax similar in all respects to the tax provided for in chapter 226, except that the rate of the tax was five per cent instead of six, as in chapter 226, passed the house in 1921 but was defeated in the senate by a vote of 28 for to 34 against.

Justification of the Tax

The "Occupation Tax Law" provides for a tax equal to six per cent of the valuation of all ore mined or produced in Minnesota. The law further provides that the taxable value of ore mined shall be determined by subtracting from the ore at the place where it is brought to the surface of the earth, among other things, "the amount of royalties paid on the amount of ore mined during the year on which the tax is based." Royalty as defined in the "Royalty Tax Law" is the amount in money or value of property received by any person for permission to explore, mine, or take out ore from mineral properties; and in most cases comes as near to being net profit as any kind of income. Moreover it is a profit derived from the same ore upon which the mine operator is required to pay an occupation tax of six per cent, and it seemed to those who sponsored the law that it was only fair in these circumstances that the recipients of royalty, who take little or no risk in the mining of the ore, should be subjected to substantially the same tax as is imposed upon those who put in all of the capital to develop and operate the mines and assume practically all of the risks. In fact, it is much easier to justify a royalty tax on moral and economic grounds than it is an occupation tax; but whether it will stand the legal tests as well, remains to be seen.

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* See page 6 of this report for full text of Occupation Tax Law.

Reports Required from Lessees and Lessors

In order to obtain the information necessary to compute the tax the commission prepared and mailed to each person and company paying royalty for permission to explore, mine or take out ore from properties in this state, blank forms upon which they were requested to make verified reports setting forth in detail: (1) the name of each person to whom they paid royalty during the year ending December 31, 1923; (2) the post office address of each such person; (3) the description of each tract of land from which ore on which royalty was paid was taken; (4) the terms of the lease under which each of said tracts was mined; (5) the number of tons mined from each of said tracts, and (6) the amount of royalty paid on each of the tracts separately. And the recipients of royalty were required to file with the commission not later than February 1, 1924, on blank forms which were mailed to each of them, verified reports setting forth in detail: (1) the names of the person or persons from whom "royalty" was received during the year ending December 31, 1923; (2) the post office address of each of such persons; (3) the description of each tract of land from which ore was taken on which royalty was received; (4) the number of tons of ore mined from each of such tracts; (5) the royalty rate per ton for each tract; (6) minimum royalty received; (7) gross amount of royalty received during the calendar year ending December 31, 1923; (8) amount of royalty paid by recipient during the year 1923 to sublessors or other persons owning a leasehold interest, together with their names, post office addresses, and the amount paid to each; and (9) the net amount of royalty received by the recipient during the calendar year 1923.

Amount of Royalty Reported

In response to our request directed to persons and companies paying royalty we received 107 reports showing royalty paid during the calendar year 1923 amounting to $16,409,042.85, and in response to our request for reports from persons receiving royalty there were filed with the commission 352 reports showing that there was received during the year, royalty to the amount of $15,409,287.03. The discrepancy in the amounts reported by these different groups is due in part to the fact that 145 persons receiving royalty failed to report, and in part to a difference of opinion between certain lessors and lessees as to whether certain payments were in fact royalty within the meaning of the law.

Validity of Law Being Contested

Twenty-nine recipients of royalty are contesting the validity of the law in the courts, and as to all of these litigants the commission has been enjoined by the court from taking any steps to enforce the law during the pendency of the suits. The cases were all tried together in the United States district court before Judge Cant, but up to the time this chapter went to press no decision had been handed down.

Amount of Taxes Certified in 1924

The total amount of taxes certified by the Commission to the state auditor as due and payable June 1, 1924, under the provisions of the law is $788,921.43; and there was also certified for failure to report within the time fixed in the law, penalties amounting to $2,227.37. Of the amount so certified, $354,116.68 has already been paid and $434,804.75 is delinquent.

Royalty Tax as Revenue Producer

It is conservatively estimated that the tax due from the 29 litigants amounts to fully $216,480.81, and if this amount and all of the other delinquent taxes are ultimately collected the revenue derived from the tax based on royalties received in 1923 will amount to fully $1,007,085.47. This is more than we estimated the average annual receipts from the tax would be when the measure was being considered by the legislature, but in considering these figures it should be remembered that the year 1923 was a banner year in the mining industry and the amount of royalty received during that year, upon which the 1924 tax is based, is nearly twice as much as was received in 1922 or 1924. It is evident, however, from these figures that, if the law is finally upheld by the courts, the royalty tax may be safely depended upon to produce each year a very substantial amount of revenue.

"ROYALTY TAX LAW"

BEING CHAPTER 226, LAWS OF 1923

An act providing for the levy and collection of a tax on royalty received by the owner of any right, title or interest in land situate in this state for permission to explore, mine, take out and remove ore from the same.

Be it enacted by the Legislature of the State of Minnesota:

Section 1. Tax on iron ore royalties—Rate.—There shall be levied and collected upon all royalty received during the year ending December 31, 1923, and upon all royalty received during each calendar year thereafter, for permission to explore, mine, take out and remove ore from land in this state, a tax of six (6) per cent.

Sec. 2. **Definitions.**—For all purposes of this act the word "royalty" shall be construed to mean the amount in money or value of property received by any person having any right, title or interest in or to any tract of land in this state for permission to explore, mine, take out and remove ore therefrom; and the word "person" shall be construed to include individuals, copartnerships, associations, companies and corporations.

Sec. 3. **Annual reports to tax commission.**—Every person to whom royalty is paid shall on or before the first day of February, 1924, and annually thereafter on or before the first day of February of each year, make and file with the Minnesota Tax Commission a report verified by the person making the same and setting forth the amount of royalty received by such person during the preceding calendar year, and such other information as said commission may require.

Sec. 4. **Contents of reports.**—It shall be the duty of every person paying royalty, on or before the first day of February, 1924, and annually thereafter on the first day of February in each year, to make and file with the Minnesota Tax Commission, a report covering the preceding calendar year, verified by the oath of the person making the same and setting forth:

1. The number of tons mined from each tract of land for the right to mine and remove ore on which such person pays royalty.
2. The amount of royalty paid on each tract of land separately.
3. The name and post office address of each person to whom royalty is paid, and
4. Such other information as said commission may require.

Sec. 5. **Tax commission to assess tax.**—Upon the receipt by the Minnesota Tax Commission of the report provided for in section 3 of this act it shall determine from such information as it may possess or obtain, whether the same is correct or otherwise, and if found correct, said tax commission shall determine therefrom the amount of tax due from such person, and shall enter the amount thereof in its records and shall make its certificate of taxes due thereon from such person, and on or before the first day of May of each year file the same with the state auditor and a duplicate thereof with the state treasurer; and the tax commission shall have power, in case it shall deem said report incorrect, to make its findings as to the amount of such taxes due after hearing upon notice to the person interested, and its findings shall have the same effect as the determination of the amount of such taxes upon a report made as hereinbefore provided.

A person subletting land for the use of which he received royalty shall be required to pay taxes only on the difference between the amount of royalty paid by him and the amount received.

Sec. 6. **Penalties for non-payment.**—If any person subject to the tax provided by this act shall fail to make the report provided for in section 3 of this act, at the time and in the manner therein provided, there shall accrue upon the tax herein imposed a penalty in an amount equal to ten per cent (10%) of the tax so imposed to be added to and collected with such tax. The tax commission shall in such case determine the amount of the ores mined or produced, together with the royalty paid thereon and shall fix the tax due thereon from such person, together with such penalty, upon such information as it may possess or obtain and shall proceed as provided by law when such taxes are determined upon the sworn report of the person receiving such royalty. Such findings shall stand in the place of the report required by this act to be made by such person and shall be in all courts of the state, for all purposes, prima facie evidence of the facts therein stated.

Sec. 7. **Date of payment.**—Such tax shall be due and payable on the first day of June, 1924, and annually thereafter on the first day of June, and if not paid on or before that date a penalty of ten per cent (10%) shall immediately accrue thereon.

Sec. 8. **Tax a lien on lands and ore.**—The situs of royalty for all purposes of this act shall be in this state; and the tax herein provided for shall be a specific lien from the time the same is due and payable upon all and singular the right, title and interest of the person to whom such royalty is payable, in and to the land for permission to explore, mine, take out and remove ore on which the royalty is paid.

Sec. 9. **Auditor to make draft.**—On or before the tenth day of June in each year the state auditor shall make his draft upon each person delinquent in the payment of such tax for the amount of taxes and penalty, or penalties, due thereon, and place the same in the hands of the state treasurer for collection.

The draft of the state auditor for the tax and penalties imposed by the foregoing provisions of this act shall be prima facie evidence in any court where proceedings may be brought for its enforcement that the amount therein stated is due the state from the person against whom the same is drawn.

Sec. 10. **Treasurer to collect tax.**—The state treasurer within ten days after the receipt of the draft mentioned in section 9 of this act shall notify by mail the taxpayer designated therein of the amount thereof and if not paid within thirty days after presentation shall deliver the same to the attorney general whose duty it shall be to bring an action thereon in the district court of Ramsey County for the amount of such draft, together with interest and costs of the proceedings. Such tax shall draw interest at the rate of one per cent per month, commencing thirty (30) days after the same falls due; and the judgment of the court when so obtained and properly docketed shall be a lien upon all right, title and interest of the taxpayer to the land upon which such tax is a lien from the time the same is docketed; and said lien shall continue without limitation with interest at the rate of one per cent per month and the said property may be sold in satisfaction of such judgment in the same manner as provided by law for the sale of property upon execution.

Sec. 11. **Penalties for false returns.**—Any person who for the purpose of evading the payment of the tax herein provided or any part thereof makes any false return or report shall in addition to the tax provided by this act pay a penalty of fifty per cent (50%) of the amount of said tax; and any person who shall knowingly make under oath any false report or return required by this act shall be guilty of perjury and upon conviction thereof shall be punished therefor as provided by law.

Sec. 12. **Records to be open to inspection of tax commission—Violations and penalties.**—All books, waybills, inventories, correspondence and memoranda relating to or used in the transaction of the business of any person paying or receiving royalty on ore mined in this state, shall upon request of the Minnesota Tax Commission be open to its inspection or examination. If any such person shall neglect or refuse on request of the Minnesota Tax Commission access to the papers and books aforesaid, he shall be guilty of a misdemeanor and upon conviction thereof shall be punished therefor as provided by law.

Sec. 13. **Taxes to be paid into general revenue fund.**—All taxes assessed, levied and collected under the provisions of this act shall be paid into the state treasury and credited to the general revenue fund.

Sec. 14. This act shall take effect and be in force from and after its passage.

Approved April 11, 1923.

Taxation

Econ

PROPOSED SYSTEM OF FORESTRY TAXATION

O. F. BARNES

REPRINTED FROM PROCEEDINGS OF THE NATIONAL
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NATIONAL TAX ASSOCIATION
1923

PROPOSED SYSTEM OF FORESTRY TAXATION

O. F. BARNES

Forest property is a long-time investment and, as an investment, differs radically in its income-producing features from most other forms of investment and is particularly burdened by prevailing methods of taxation.

The most important consideration with respect to every long-time investment is — what will be the future cost of carrying the investment? Any uncertainty as to future carrying charges invariably outweighs promises of large profits. Uncertainty as to the future cost of carrying a forest property investment is very largely a question of taxation.

Ad valorem property taxation inflicts greater hardship upon property not yielding a regular income, or where income must be left to increased capital than it does upon property yielding a regular income. In the case of forest property the non-income-producing period may extend over many years.

Ad valorem property taxation applied to forest property necessarily results in over-taxation of such property, as compared with other forms of real property.

Standing timber in all essentials can only be considered as a crop, and like the wheat crop or the corn crop, has no economic value until severed from the soil. Theoretically, therefore, and as a matter of justice, land devoted to a timber crop and land devoted to a farm crop should be affected in the same way by just and equitable taxation. This is impossible when both classes of land are subject to unmodified ad valorem taxation. The wheat crop or the corn crop matures and is separated from the soil annually. The growing and maturing of a timber crop is a matter of years. The annual farm crop provides income with which to pay the annual tax. During the maturing of a timber crop there will be many tax rotations with no crop furnishing income from which to meet them. The unsevered farm crop in practice is never taxed, and its presence in any state of maturity has no influence on the annual taxation of the land producing the crop. A farm may be cropped and taxed under the ad valorem general property tax system for fifty years and during that period no growing crop would be taxed and no assessment increased because of the growing crop. The assessment of the farm for taxation would simply be the income-producing capacity of the soil, capitalized. In determining the assessment for taxation purposes of land devoted to a growing timber crop, the assessing officer annually capitalizes the crop-producing capacity of the soil and also whatever progress the timber crop has made toward maturity. In determining the assessment for taxation of a mature forest, where nature has established a balance—growth and decay equalizing each other—ad valorem taxation annually capitalizes the crop-producing capacity of the soil and the entire income that will be produced. In both cases the result is, comparatively speaking, continuous over-taxation.

The economic effect of increased taxation upon forest property is far different from the effect of increased taxation upon other forms of real estate. It forces destruction, not development. If taxation is increased on non-income producing city property the owner can improve the same and thus obtain income to meet the increased tax, and in so doing he benefits both himself and the community. If taxation is increased upon non-income producing farm lands the owner can put the same under crop and obtain income to meet the increased taxation, again benefiting both himself and the community. The owner of forest property, however, when taxation increases, can obtain income from the property to meet such charges only by destroying the property.

Forest property, therefore, as an investment, differs so in character from other forms of real estate investment and is so adversely affected by annual ad valorem taxation that cessation of premature and wasteful cutting of mature forests and profitable reforestation of cut-over lands depends absolutely upon modifying our system of taxation.

Many states have recently enacted legislation for this purpose, but study of these laws, in almost every case, discloses that legislators have failed to recognize either the economic principles that control long-time investments or the fact that ad valorem taxation of timber lands invariably results in over-taxation. Law-makers in most states have not been confronted with vast areas that must be reforested through natural reproduction of forest growth, if reforested at all, and they have aimed not so much at developing an equitable system of forest taxation as at encouraging the practice of forestry through special favors. A just and enduring system of forest taxation cannot have for its basis special favors to the owners of forest land. That class of property must, in the long run, pay a total of taxes equivalent to that paid by other classes of property of equal value. What should be done in framing forestry taxation is to take into account the particular character of forest property and the destructive results of certain forms of taxation upon it and frame tax laws in harmony with such character and conditions.

I suggest as basic principles of forest taxation:

First — That forest property must not, through ignorance of its character and of the effect of ad valorem taxation upon it, be overtaxed.

Second—That taxation be so framed as to enable the investor in forest land to calculate with reasonable certainty his future tax burden until such a time as he can realize income from his investment.

Third — That the payment of taxes be arranged, as far as possible, for a time when income may be expected with which to pay the tax.

Fourth — That the interests of the owners of other classes of property and the interests of the political units where forests are located be given proper consideration.

The particular form of taxation that is most frequently urged is: Exemption of land and timber from the annual ad valorem general property tax and the substitution therefor of a percentage tax upon yield, payable whenever any part of the crop is harvested.

The substitution of a percentage yield tax for all other taxes would be the simplest solution of the problem but it does not meet the fourth requirement: "That the interests of the owners of other forms of property and the interests of the communities in which forests are located must be given due consideration."

The yield tax necessarily implies an irregular local revenue from all forest property, inasmuch as there would be no revenue from such property except when there was harvesting of forest products; and in districts where forests constituted any considerable portion of the taxable property, failure to receive any annual revenue from such property would work hardship. Again, the unmodified yield tax is open to the objection that forests are not all alike but vary from newly established growing forests, containing no merchantable products, to mature forests of virgin timber that may be harvested with profit. There is rarely any dividing line. There will generally be found some merchantable forest products upon cut-over lands and there will be much immature growth in virgin forests. Again, the uses for forest products are so varied that what is immature and useless for one purpose may be matured and useful for another purpose.

We have declared it fundamental to correct forest taxation that immature forest growth shall not be subject to annual ad valorem taxation while coming to maturity. On the other hand, there is no economic justification for exempting from annual taxation mature forest growth that can be made to yield income. It is equally fundamental that land shall not be exempt from annual taxation, because devoted to any particular crop. The interest of those owning other kinds of property and the interests of the political units, where forests are located, demand that some annual revenue be contributed by forest property. The principle that all property must, in the long run, contribute equally to public expenditure is not violated by deferred taxation such as a yield tax, providing the yield tax is so administered as not to impose double taxation. We cannot satisfactorily classify forests but we can, where land is devoted to forestry, determine the value the bare land would have and the value of mature forest products on such land and use such values for determining an annual tax upon land and an annual tax upon mature forest growth. With these suggestions in mind, we can so modify the yield tax that fundamental requirements, such as prevention of over-taxation and double taxation, no annual taxation of immature forest growth, and certainty as to future taxation costs, may be preserved and payment of the greater part of the tax which forest property should eventually pay, be arranged to come at a time when income can be derived from the property, and at the same time some regular annual revenue from forest property be provided for the use of the local political units.

The formula for a yield tax, modified in harmony with the above suggestions, would be as follows:

Determine separately bare land value and merchantable timber value; bare land value to be the same as the assessed value of wild, unimproved bare land of similar quality in the same locality; merchantable timber value to be the stumpage value of merchantable forest product upon the land; immature forest growth not to be considered in determining either land value or merchantable timber value.

An annual tax at a fixed sum on land value thus determined.

An annual tax at a fixed sum upon merchantable timber value thus determined.

A percentage tax upon yield, payable whenever any of the merchantable forest products are harvested; but no yield tax to be imposed until forest products to the amount of the original appraisal have been harvested.

Land value not to be changed, except after regular fixed intervals and then only for the purpose of harmonizing such land value with the assessed value of bare lands in the same locality.

Timber value not to be increased at any time but to be decreased, as merchantable forest products are harvested; such decrease to be the stumpage value, at the time of harvesting, of the forest products removed from the land.

This combination of a fixed annual land tax and a fixed annual mature timber tax and a yield tax is logical and just. It prevents over-taxation, by not allowing taxation of immature forest growth. It prevents double taxation, by providing that no yield tax shall be paid upon forest products that have been subject to the annual merchantable timber tax, until the merchantable timber value as originally fixed has been extinguished by cutting. It both encourages and enables the owner of mature forests to delay cutting them, by fixing the future tax burden upon such lands and preventing any increase in such fixed charge. It meets the requirements that the investor shall be in situation to calculate with reasonable certainty the future cost of carrying his investment, by fixing both the rate of taxation and the valuation upon which it is to be computed. It protects the interests of the owners of other classes of property and the interests of the local community, through the annual land tax and mature timber tax. To fix for a term of years the amount of the annual land tax, basing it largely on what such land is now paying, is no injustice, because the greater part of the land that would be made use of for forestry would be, at the time of coming under the new system, cut-over and waste land, paying a small tax, and, because of conditions that generally operate upon waste land when unoccupied and unprotected, would, in most cases, remain waste land, with little new growth that would add to its value and increase the tax. Under such conditions, to continue the tax at practically the same amount after its dedication to forestry would be no injustice.

The provision that where a valuation had been determined upon for the taxation of mature timber, such valuation can be gradually reduced and eventually extinguished, through the harvesting of mature forest products, creates the most practical opportunity for establishing and maturing a growing forest. By harvesting at any time such portion of the merchantable forest products as will equal in value the timber valuation as originally determined, the mature forest will automatically take on the status of a growing forest, with no timber valuation to be taxed; and this regardless of the fact that because of the growth of what was immature at the time of the valuation and because of a natural increase in the value of products, there might be almost as much actual timber value remaining as there was at the time of the appraisal. From that time on a timber crop can be harvested at regular intervals and the only annual tax will be upon bare land value.

It is not necessary to discuss rates of taxation under such a system. The question of administration, however, is a matter of the highest importance, especially the determining of bare land value and merchantable timber value. Such valuations, because not subject to change over a period of years, must be correctly determined and made as uniform as possible throughout the state, and this cannot be done by local assessors. The board of state tax commissioners should administer this feature of the proposed system. and they should also determine the stumpage value of forest products harvested, and with that information in their possession they would also determine when original merchantable timber values, subject to annual taxation, had been extinguished.

In studying the systems of other states I have found that no matter how carefully and correctly forest taxation laws may have been framed they have accomplished little, because the land owner has had to elect to come under such laws. If all land more valuable for forestry than for other purposes were automatically placed under the proposed forest taxation law, and the land owner had to elect to withdraw his land or have it permanently classified as forest land, the situation would be far different. In Michigan the conservation department of the state has a bureau known as the Economic Soil Survey Bureau, and they are taking up county after county, and classifying the land. They have one class in which they place all land which they consider more suitable for growing forests than for agriculture, and it is suggested that the proposed law automatically apply to lands they have so classified. Inasmuch as this survey cannot be completed for several years, it is also proposed that individuals may offer their lands for classification as forest land before they are considered by the Economic Soil Survey, and if the lands so offered are approved for forestry purposes by the conservation department, they also would come under the proposed law. It is recognized that many land owners may prefer to make other use of their property, even though it has been classified as more suitable for forestry than for any other purpose. The opportunity, therefore, should be given such land owners to apply to the state tax commissioners and have such lands removed from classification as forests. But in case such application is not made within a certain period, such land will be considered permanently classified as forest land, to be removed from that class only on payment of a proper fee, based upon the number of years it has been so classified.

The question as to how taxes paid on forest property should be distributed has much bearing upon the success of such a taxation system. If, out of the annual land tax, an annual tax upon merchantable timber, state and county taxes should first have to be paid, the portion remaining might not be sufficient for local requirements. To remedy such a situation, it has been suggested that all the annual land tax and all the annual merchantable timber tax should go to the townships and school districts, where forests are located, and that the yield tax be distributed on some percentage basis, between the state, the county and the school district.

Influences 7.3
Planting 2.54
Improvements Engineering 4.44

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Influ

THE FIXATION
OF THE
DUNES OF GASCONY.

BY

ÉDOUARD HARLÉ.

Extract from the "Bulletin de la Section de Géographie," 1914.

Translated from the French by RUTH M. D. MCINTYRE and E. PHILLIPS TURNER, F.R.G.S.

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Taxation

Econ

PROPOSED SYSTEM OF FORESTRY TAXATION

O. F. BARNES

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1923

THE FIXATION OF THE DUNES OF GASCONY.

THE dunes which border the ocean on the coast of Gascony have been fixed by successive sowings of maritime pine from 1787 to 1864. Accounts of these remarkable works have already been given by Lefort[*] and Laval,[†] Engineers of Bridges and Roads in 1831 and 1847, from their personal experience, and more recently by Grandjean,[‡] Inspector of Forests, and by Bert,[§] Administrator of Forests. Their works, although extremely interesting, have far from exhausted the question. Living at Bordeaux, for many years I have chosen these dunes as places of excursion, and I have examined files of papers about their fixation. These files, indeed, are at Bordeaux in the records of the Conservation of Forests, and I have been able to consult them, thanks to the kindness of the Conservator, M. de Lapasse, whom I cannot thank enough. Such is the origin of the present note.

To understand it, it is useful to indicate briefly who executed these works and when they were done.

HISTORICAL.

The first fixation of the dunes on the coast of Gascony was commenced by Brémontier, Engineer of Bridges and Roads, on the 12th March, 1787, along the basin of Arcachon, near Moulleau.[||] He continued it there on a total length of about two miles and on an area of about 232 acres. The work was stopped on the 5th March, 1793, because "the chest was empty." This fixation was done by sowing, with certain precautions, seeds of maritime pine.

The work was resumed in 1801 under the energetic impulsion of the First Consul: a by-law of the 13th Messidor, year 9, signed "Bonaparte," charges with its carrying-out a Commission, centred at Bordeaux, comprised of the Chief Engineer of Bridges and Roads, President (Brémontier), of an Administrator of Forests (Guyet-Laprade), and of three members of the Society of Science, Literature, and Arts of Bordeaux, chosen by their fellow-members. The work was undertaken simultaneously at five points—Verdon, Cape Ferret, Arcachon, Patchon (near La Teste), and Mimizan. This Commission had charge of all the dunes that were in the Department of Gironde or in that of Landes. But in 1808 the Department of Landes was entrusted to a similar Commission centred at Mont-de-Marsan.

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[*] Lefort: "Notice on the Works of the Fixation of Dunes." Public Records of Bridges and Roads, 1831 (latter half-year).

[†] Laval: "Memoir on the Dunes of the Gulf of Gascony." Public Records of Bridges and Roads, 1847 (latter half-year).

[‡] G. Grandjean: "The Heaths and Dunes of Gascony." Social Bulletin of the Society of Commercial Geography of Bordeaux. 1896.

[§] J. Bert: "Note on the Dunes of Gascony." Department of Agriculture: Universal Exhibition of 1900 at Paris.

[||] These works have been paid from a credit of 50,000 livres, opened the 26th ptember, 1786, by the Controller-General of Finance, "to be employed in work which s for its object the assurance of the possibility of the making of a canal projected in e heaths, and the finding of means for fixing the dunes." During the reign of uis XVI, and even before, people were greatly occupied in fixing the coastal dunes Gascony and in rendering them healthy, and putting under cultivation, by means drains, its vast heaths. These works were started as branches of the establish- nt of navigation-canals in this country, and it is perhaps for that reason that Administration of Bridges and Roads, and not that of Forests, was charged with fixation of the dunes.

The work of these Commissions has been fruitful, but accompanied with personal wranglings. It was "to establish order and unity" that an order from the King dated the 5th February, 1817, charged the Administration of Bridges and Roads with this work. The Chief Engineer, until then President of the Commission of the Department, became head of the service. This organization was preserved till 1862, when, this immense work being almost completed, an Act of the 29th April made over all this service to the Administration of Forests, considering as "logical" that it should be "charged with the duty of keeping in repair, improving, and exploiting a domain which is to-day transformed into a wealth of forest." The Administration of Bridges and Roads had besides made over to the Administration of Forests areas for a long time covered with trees.

The files that I have examined are those of the Administration of Bridges and Roads. They deal with all the works of fixation since their commencement in 1787, with the exception of the part done by the Administration of Forests after 1862. I have noted especially in them, for the period after 1817, the Engineers Le Boullenger, Jémois, Goury, Deschamps Sons, Pairier, and Ritter. I have had pleasure in finding there a sketch of my grandfather, the Engineer Partiot, who in 1828–30 fixed several dunes at Sablonney and at Piquey, in the basin of Arcachon.*

The merit of Brémontier has been disputed. It is upheld that the fixation of dunes by pine sowings was pointed out before him by de Villers. But the theoretical process that de Villers has described does not include the covering of the ground with boughs. This covering is one of the elements of the Brémontier process, and it is very necessary, at least in the atmospheric conditions of Gascony, for in spite of its very increased cost it was employed till the end of 1864. Desbiey, also before Brémontier, occupied himself in writing a memoir of the fixation of dunes; but his manuscript is lost, and we do not know his process. Finally they supposed that the covering was invented by Peyiehan (pronounced Pejan), the local agent of Brémontier; also, that it was already employed in the country. At any rate, it is Brémontier who, by his systematic experiments (the only rational way), has discovered what operations should be adopted; it is he who has stirred up public opinion and powers and has prepared this immense work which has continued, without any check, to its complete achievement.

Dejean, the son-in-law and the successor of Peyiehan, gives the following account of the very first works of Brémontier:—

"They began in the outset to make small fences of brushwood (*clayonnages*), made in the form of a horse-shoe placed on the white sand at a distance of 10 metres behind one another. In their middle, seeds of pine and broom were sown, which germinated; but when a rather strong wind came it moved the sand, uprooted the young plants, and overwhelmed a number of the small brushwood fences, or overturned them. The impossibility of fixing the dunes without a covering was then seen."

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* A new sand-dune actually invaded the forest which he created at Sablonney.

A note from Brémontier of the 21st April, 1787, had enjoined the trying of these small brushwood fences on one dune and the branch covering (*couverture*) on another.

DESCRIPTION OF THE DUNES.

The chain of dunes of the long and flat coast of Gascony stretches approximately north and south, as does this coast, from the mouth of the Gironde to that of the Adour, and even a little farther, to the rocks of Biarritz. It thus borders on the departments of Gironde and Landes, and for some kilometres on the department of Basses-Pyrénées. Its length is 240 kilometres, and its width varies from 4 to 8 kilometres, except at its two extremities, where it diminishes. A good number of these dunes are more than 70 and 80 metres high. One of them, Sablonney, rises quite abruptly to almost 100 metres above the basin of Arcachon. All the dunes of this chain have been created by quartzose sand thrown up on the beach by the sea, which is carried along by sea-winds—that is to say, westerly winds, or rather winds varying from south-west to north-west. This wind is, moreover, by far the strongest and most frequent.

A part of the dunes on the inner border—the eastern border—of this chain is covered with forests so ancient that they seem to have always existed. These ancient-wooded dunes, called *dunes anciénnes*, have either the form of parabolas with their axes from west to east—that is to say, parallel with the wind, with their apexes towards the east (first noticed by Durègne some years before)*—or else similar forms. They are the result of the transformation of former dunes which, being covered spontaneously with a certain vegetation, could be attacked only locally by the wind. This local attack by the west wind developed there, scooping out the dune and throwing out the scooped-out matter to the front and to the sides, and the result of this work has been a parabola or a similar curve. This hollow, with the dune which results from it, is called by the Germans *Windmulde* (a valley in the form of a bowl hollowed out by the wind), and I have proposed to call it by the Gascon term of *caoudeyre* (saucepan), as I have heard it called by the people of the country. The old dunes are often called "primary dunes," but from the evidence of their shape they are, as I have just explained, secondary. They exist in more or less important groups, scattered throughout the length of the chain of dunes; but they are especially developed to the south of Léon, because in that locality the supply of sand from the sea has been stopped by a deviation of the Adour, which flowed close to the coast. This has favoured the growth of vegetation.†

But we have to occupy ourselves solely with the other dunes, far more extensive, which were bare and mobile at the time of Brémontier—the modern dunes.

"The general aspect of the dunes," writes Laval, who saw them from C ntis to Biscarrosse in 1830–35, "is very remarkable. After crossing t vast desert of large heaths, they are seen delineated in the sky a l shining at long distances across the sombre green of pine forests—o might even think he saw high chains of snowy mountains, with their s dles and rounded peaks; and the illusion is all the greater as the traveller finds himself in a boundless plain where no point of comparison can make him realize their true height. The inner aspect of the dunes, seen from one of the summits of the eastern chain and looking towards the sea, offers an image of chaos and inexpressible disorder, without the eye being able to rest on the slightest trace of vegetation; one thinks one sees gigantic waves made by a raging ocean, whilst at the horizon the still sea is ploughed by ships with white sails. It is one of the most beautiful and striking pictures given for man to admire."

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* It was while making a plan of the "Forêt Usagère" of La Teste that M. Durègne n ed this shape. One may consult with profit on this subject the plans that he has p hed of this forest.

In 1578 the actual direct course was pierced by the Engineer Louis de Foix.

Whilst on a visit to the dunes to the north of Léon, in 1809, the Commission was struck by their extreme desolation: "Here nothing lives; nothing else is found but silence."

All descriptions of these dunes before their sowing are like those that I have just reproduced. But unluckily the dunes were not fixed; they were changing their place towards the interior of the country—towards the east. Le Boullenger, in a report of 1817, has distinguished two kinds of them—the flat and the high.* Both have a gentle western slope. They differ in their eastern slope. The eastern slope of "flat" dunes is gentle. These dunes advance, keeping this slope, with great rapidity. The wind keeps close to this slope. The dunes which he calls "high" have, on the contrary, an eastern slope "almost perpendicular," and they advance slowly, keeping this slope, through its slipping down in successive slices. This slow and irresistible progression covers over the ground to the whole height of the dune—that is to say, 15 to 30 and even to 40 metres. The wind leaves the dune from the summit. Most modern dunes are of this kind. They have a shape like long waves, similar to the waves of the ocean, a resemblance which has struck all observers; and it seems to me that the expression "dune-waves" would describe them better than "high dunes" chosen by Le Boullenger. One could, I believe, describe the very steep slope with which they advance by the expression "wall of encroachment." I have drawn in outline these two kinds, with the path of the wind (figs. 1 and 2).

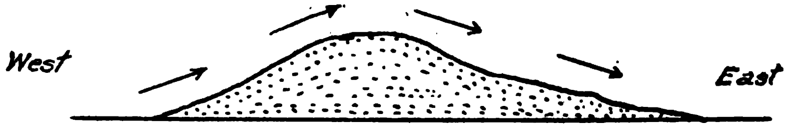

FIG. 1.—Flat dune.

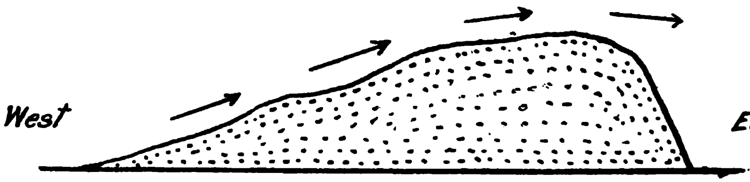

FIG. 2.—Wave dune (high dune).

I have believed for a long time, on the testimony of books, that sa must be dry to be displaced by wind. But two elements influence th displacement: one is indeed the dryness of the sand, the other is the strength of the wind. On the coast of Gascony the strong winds are those of storms which have come from the sea and are accompanied by rain. In fact, the big displacements of sand are produced by these storms, and consequently the sand is, for the greater part, put in motion in a certain state of humidity. I arrived at this conclusion by numerous examples, old and new. I will confine myself to an old example. Jémois, in January, 1820, wished to visit the dune of Carquebin, near Mimizan, situated 3 kilometres from the sea, and which he had to fix. "On the 28th," writes he, in the report of his rounds, "the wind blew very strongly from the north-west, accompanied by rain. 'Although the weather was fearful and the sand flew in an extraordinary manner we continued our inspection and ascended the dune of Carquebin to judge well the effect of the wind."

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* I have published this report of Le Boullenger in "Actes de L'Académie Sciences, Belles-lettres, et Arts de Bordeaux," 1914.

When this wet sand reaches the edge of a dune-wave, that part which is not borne afar agglomerates, forming a very steep slope there. Then this mass, becoming too heavy, falls down in patches. People sheltering themselves from the wind at the foot of this "wall of encroachment" have been entombed under such slips. Le Boullenger mentions two hunters, and Laval mentions a shepherd, who perished in this manner.

When the summer approaches the sand becomes dry, and the steepest slope on which it can hold becomes more gentle.* Then the sand of the wall of encroachment runs in little streams until the wall has lost its steepness.

These details of the progression of dune-waves are described in several articles in the files, and I have been able to see them in action at the dune of Sablonney and at the coastal dune of La Salie, to the south of the basin of Arcachon. In the same order of ideas, every one knows that children make sand-balls with wet sand, a thing they could not do with dry sand.

The dunes are separated by level, horizontal intervals called *lettes*. These *lettes* are filled up firstly by the sand from dunes which, while going forward, have covered and uncovered their sites; secondly, by the sand carried higher up than and beyond the dunes, which, falling, sprinkles the earth; and lastly by sand which has run down to the surface of the earth. Many *lettes* are made uneven by knobs or even by quite important dunes. Before the time of Brémontier several *lettes* between mobile dunes were already overgrown with old trees; others, on the contrary, had quite a mobile surface; most were covered with a moderate vegetation.

The mobility of "modern dunes" was very harmful to the populace from two points of view: in the first place these dunes encroached on dwellings, cultivations, and forests; in the second place they obstructed the flowing of water. The encroachments on forests were continual, those on cultivations and buildings were rare; and Saint Jours, text-book in hand, from the exaggeration of oral traditions has got the truth.* It is necessary, however, to note that in 1812, near Mixe, at a distance of 5 kilometres from the sea, an ancient church, buried of old by a long-forgotten dune, reappeared through a new displacement of this dune.†

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* This is because the sand of our dunes has a certain adherence when it is wet, but not when it is dry. Example: I fill a cylindrical tube with this wet sand; then I hit he tube, with little repeated taps: the sand does not heap up. I do the same thing gain, but this time with dry sand: it will pile up at the eighth tap. This adherence f our wet sand seems to me to have an interesting result. It is known that the great arthquake of San Francisco of 1906 was particularly disastrous for buildings on mbankments and other places susceptible of subsiding through shocks. At Arcachon any villas are built on a dune which is quite high. If the sand was dry this dune ould slip down through earthquakes—indeed, even by the shaking from motor-agons. The villas would be endangered. But no shaking could do it, save exceptional rthquakes like that of San Francisco, because the sand is always wet starting from epth of several centimetres.

The damage caused by obstruction to the flowing of water, on the contrary, has been continual and considerable. The barrier that this long chain of dunes forms, stopping the flow of water from the whole country, has promoted from time immemorial the formation of lagoons—two of which are the biggest lakes in France‡—and has forced the waters to follow the edge of the dunes. There are but few outlets through the dunes: that of Arcachon, kept free by the important river Leyre, where the waters from the north meet after having skirted the dunes for 52 kilometres; that of Mimizan, which drains waters whose length parallel with the dunes is 38 kilometres; those of Contis, Léon, Vieux-Boucau, and Capbreton. The advance of a single dune repels the current, both in the long brook, called the "course" (*courant*), which skirts the dunes, and in the "course" (*courant*) which traverses them, thus promoting the raising of the waters up-stream, and the country being flat it follows that an immense surface is submerged. The water-courses which, skirting the dunes, met at the outlets of Arcachon, Mimizan, and Contis have even been crossed or broken through by isolated dunes: such a dune, in fact, having much advanced, the waters, flowing back, have again taken their former course behind the new position of the dune, perhaps with the aid of the inhabitants who were the victims of the inundation.

In general the action produced was less abrupt: the dune, flat or high (a dune-wave), advancing on the stream, the water carried away a proportion of the sand with which it was encumbered, but only to deposit it fifty or a hundred paces down-stream.

"The dune," writes Le Boullenger, "makes scarcely any further progress, but the bed of the stream is raised, its current diminishes, it has less strength to carry away the sand, which advances, driving back the stream, which swells, changes its bed, and the lower lands are covered with sand, the upper with water."

Lastly, these "courses" at their discharge into the sea have always had a great tendency to be prolonged parallel with the shore. It is thus at the present day that the "course" of Léon skirts the beach towards the south a short distance, that this deviation develops progressively, and that it attains a length of 4 kilometres, which increases every day.* This state brings about a rising of the stream waters on account of the fall which is necessary for their flow on this length, a fall which is, moreover, augmented by the current having to transport the sand which is brought into it by the wind from the sea.

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* Saint Jours: "Vanished Maritime Localities of Gascony." Philomathical Review of Bordeaux and the South-west. 1906.

† At the place called Lette of the Old Church. I regret to be unable to give here the text of the rather long official report of Boulart, the Inspector of Dunes, and of a letter from the prefect. They prove this reappearance, and show how much the prefect was pressed to demolish these remains of the church—either to sell them or to use the material.

‡ The lagoons of Hourtin and Cazaux, whose surface, now reduced by reclamation, is still 5,923 and 5,608 hectares, according to Delebecque, in "The French Lakes," 1898. I take this opportunity of remarking a fact which may serve as an indication of the way in which certain palaeontological strata are formed: Le Boullenger, in his report of 1817, relates that he followed in a barge the marsh by which the Cazaux Lagoon flows towards the Little Lagoon of Biscarrosse: "Not the slightest current was felt," he wrote. "The depth everywhere was about 2 or 3 metres . . . to right and left were thick forests of aquatic plants whose interlaced roots form a very solid floor, on which I walked with perfect confidence; however, it is necessary to keep a sharp lookout for holes—one would be lost beyond recall." I have myself visited this marsh many years ago. I was advised to be very mistrustful. Cows, they said, went there to pasture, attracted by the freshness of the grass; but now and again one of them sinks in, and in a moment disappears for ever.

GENERAL SKETCH OF THE WORKS.

The first works had for their object the fixation of the dunes that were attacking houses and tillage, and particularly those dunes which were closely menacing the large market town of La Teste. At first little attention was given to the encroachments on forests. But the works had quickly to be turned in the direction of fixing the dunes, which, encumbering the "courses," provoked the reflux of the waters, and in consequence the inundation of numerous houses and immense surfaces of country. The streams, receiving no more sand from these dunes, cleared away (eroded) their beds, and thus the level of the waters was lowered higher up. By this alone the lagoons of Cazaux and Biscarrosse, which are at the source of the stream of Mimizan, were lowered 1 metre. In order to minimize this result the numerous artificial barriers established by the inhabitants to facilitate fishing were destroyed and the bed cleared of all obstacles. A rectilinear and regular bed was even scooped out for the stream which empties itself into the basin of Arcachon. The lagoons of Hourtin and Lacanau, which are the source of this stream, dropped about 2 metres.

In fine, all the streams that wind along the shore have been straightened by trenches conducting them straight to the sea, whose banks have been fixed by timber-work and masonry. No work of this kind has, however, been done at the Léon Stream. Lefort (*l.c.*, p. 323) tells us that the trench made for the Mimizan Stream was scooped out chiefly by the wind, the action of which was promoted and directed by palisades, as indicated in fig. 3.

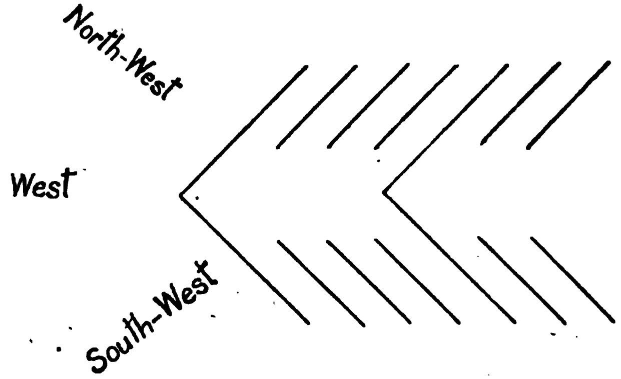

FIG. 3.—Excavation of sand effected by means of palisades.

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* I have followed all this stream. Its discharge into the sea is made very obliquely y a light inclination of its course, so that even there it flows almost parallel to the ea towards the south. So doing, it attacks and erodes the soil on its left bank and n front of it—that is to say, to the east and to the south. Also, the deviation proesses, in short, not at the cost of the seashore, but at the cost of the soil, wooded ith pines, dunes included. When I visited it the Customs post of Moliets, built on a ne, was thus much threatened. At the same time the very long tongue of sand ich constitutes its bank on the seaward side was growing longer, accompanying it vards the south, and this tongue raising itself into a dune, its [*i.e.*, Moliets'] relief as becoming important. It is probable in some analogous manner that the Adour used nerly to discharge at Capbreton, at Vieux-Boucau, and perhaps even opposite Léon.

"The palisades," he writes, "were disposed in the shape of a fan . . . some running from north-west to south-east, and the others from south-west to north-east. At intervals corresponding palisades were prolonged till they met, forming funnels, thereby concentrating the action of the wind. By means of this construction the winds from south-west to west drive out the sand by one system without being able to introduce it by the other. The winds from north-west to west have inverse action. . . . The most satisfactory results have crowned this ingenious conception, and the fruits thereof can be appreciated over a distance of several thousand metres."

Having thus done what was most pressing, and the solicitations of the people becoming less urgent, it was possible to proceed to fixation in a systematic manner. For the plan to be followed there was a choice of two things. The most rational, it seems, was to begin fixations on the coast and continue them successively towards the interior. The progression of sand was thus arrested at its start, and each work was protected by the preceding one against encroachment. But with this plan the dunes continued to encroach upon the land right up to the preparation of the last work. It was therefore preferable to commence on the landward side of the dunes and place successive works from the interior to the sea. But it was indispensable that at each work measures should be taken to defend it towards the west against the encroachment of the sands.

SKETCH OF THE WORKS *(ATELIERS).*

Let us now see in detail what steps have been taken. It is out of the question to follow every slight variation. Let us therefore take as a type a work of the last period—that is to say, of the time when methods had reached perfection; or, rather, let us take two of them in order to see the different cases that presented themselves. The best thing would be to visit at length these works during their construction, and to receive on the spot detailed explanations from the Engineer. But the works in question were finished more than fifty years ago. The dunes whose mobility we wish to see being combated are fixed by a forest of great pines which has been worked (commercially) for a long time. We must therefore resort to the files. I have chosen the two following: Works to the west of Lacanau (Gironde), 386 hectares, designed by the Engineer Pairier, 8th April, 1853;* and, for supplementary explanations, the Biscarrosse (Landes) Customhouse works, 578 hectares, plan drawn up by the Engineer Ritter, 18th April, 1851.

Plates I and II reproduce the plan of these works. These two works are bounded on the east by the seed-plots of completed works. They have not, therefore, to fear the encroachment of sand coming from that side, since the soil there is fixed. Besides, the sand does not come from the east.

On the west the Lacanau works terminates in a long flat (*lette*) nor and south, the Alexander flat. There is therefore no need to fear t advance of sand on this side either—at least, not so long as the f is not overwhelmed altogether by the dune situated to the west. Besid care will be taken later on to fix this dune by a new work before th can take place.

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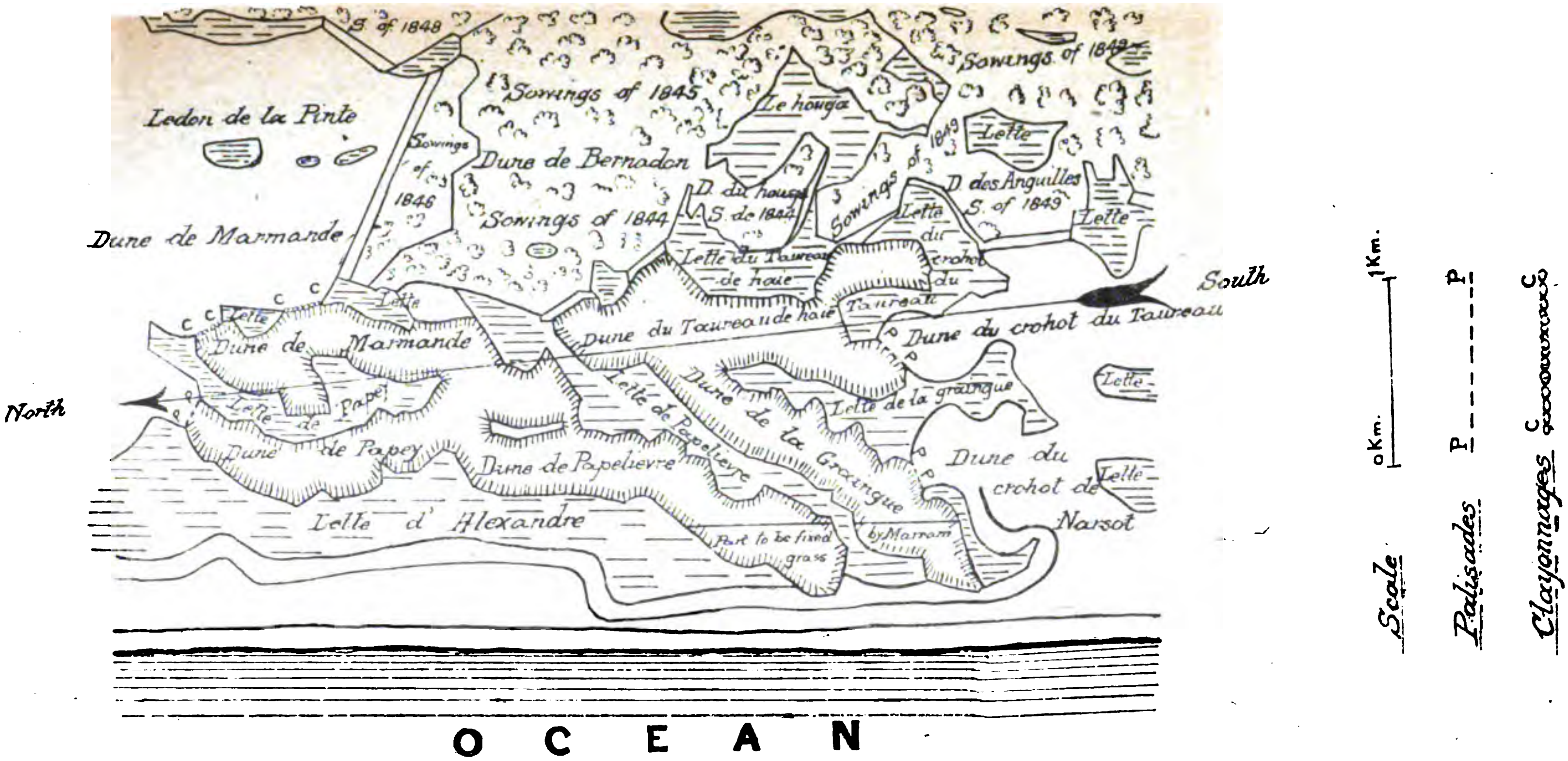
* The bathing-station of Lacanau-Ocean is built on the southern extremity of site of these works.



Plan I.—Lacanau Works.

The plan shows the works in two parts, each of which is delineated by hatchings. Long parallel hatchings indicate *lettes*.

The dunes of the Biscarrosse works having only small flats it is necessary for these works to extend right up to the sea. There it is defended against the formidable attack of the sea-sands by a palisade of planks, which arrests the sand. When the palisade is thus almost covered, the planks will be raised so that they are always a good deal higher than the soil, and so can continue to stop the sand. The accumulation of sand in several years is so great as to constitute a dune along the sea, the "littoral dune."

To the north and south of our two works the encroachment of sand has to be feared wherever the boundary of the works is upon a dune. On all these portions it is necessary to establish along the boundary a palisade ("defilading"), which arrests the sand coming from that part of the dune still mobile. These defences are but little developed at the works of Lacanau, which is rich in flats, and even several facing almost due east did not need to be more than wickerwork *clayonnages*, which is less costly. But at the Biscarrosse works, on the other hand, which are poor in flats, they have to be of great length.

The laying-out of these defilading palisades has been designed according to a very important principle. Let us take for example the palisade, 1,650 metres long, which defends on the north the Biscarrosse works. It extends from the north-west to the south-east between the sea and the Grands Lamanches flat. The winds from south-west to north-west, which are the dangerous winds, and the south winds, cannot cover it with sand, since they only reach it across the works where the sand is fixed. The north winds alone could load it with sand. But the north-west wind, which is very strong, having exactly the direction of the palisade, will scoop out at its foot on the outer side a long trench, and this will serve to receive the sand that the less dangerous north wind may bring. Similar means assist to defilade the southern part of the works, following lines from the south-west to the north-east.

In my excursions I proved that, in spite of the application of this principle, the palisades promoted great accumulations of sand. I followed these defilading palisades of the Biscarrosse works. The filling-up they promote is feeble or nil, it is true, amongst the dunes, but rises rapidly to a height of several metres on their easy slope to the west: it [the filling-up] is like a road embankment 2 metres wide. When it reaches the height of the dune it continues there to the peak of encroachment, and beyond it, thus prolonging itself in a cape 30 to 40 metres long. Besides, it really seems in places—and notably in the portion included between the fire-guards Nos. 1 and 2 (parallels) and Nos. 12 and 13 (perpendiculars)—as if the part of the dune not fixed had continued to advance after fixation of the works, producing in the

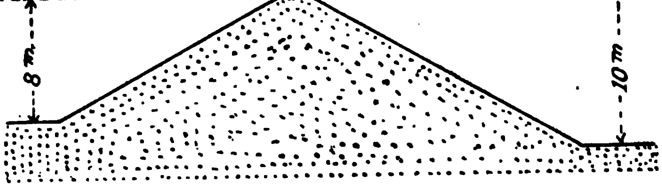


FIG. 4.—Outline in section of an embankment produced by a palisade at Biscarrosse.

dune a sort of clipping like a horizontal excavation. Farther on, towards the interior, I continued following the defilading south of the works called Biscarrosse South, which were established to the east of ours eight years before. Its palisades were laid down in conformity with the principle, and nevertheless the embankments are very high. It was there I took the bearings for fig. 4. At the summit of the dune, fixed at 67 metres, this embankment stands out so that a tower has been built on it where watch can be kept for forest fires.

At 8 kilometres to the north of Lacanau-Ocean I followed the direction of one of these defilading palisades, strictly aligned according to the principle. It is exactly occupied by the fire-guard No. 12, and, beginning at 1 kilometre from the sea, it extends as far as the forest of the Old Dunes, a length of 2,740 metres. In spite of the direction being theoretically excellent, the embankment is enormous. I give its section in fig. 5. At another point its height is 5 metres at one side and 13 metres at the other. As the object of this fire-guard is to prevent the outbreak of fires, the foresters carefully keep it clear of all vegetation and debris. This has recently led to its being scoured by the wind, and I was thus enabled to see in the axis of the embankment a large number of planks which had constituted the palisade in about 1855.

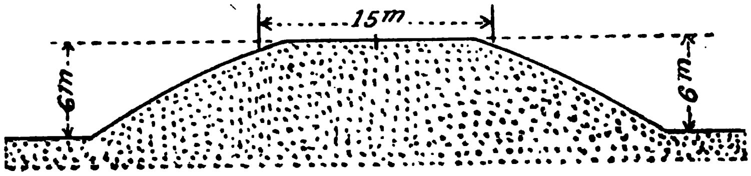


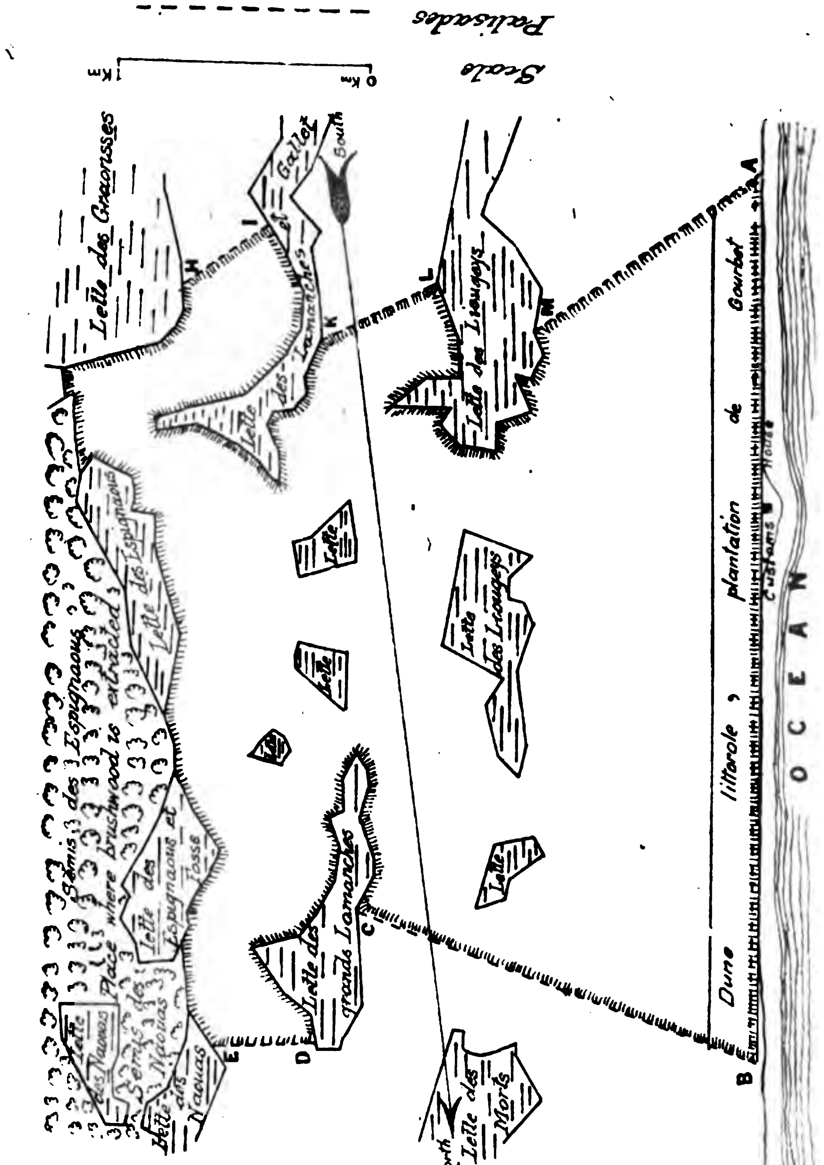
Fig. 5.—Outline in section of an embankment produced by a palisade on the border of the communes of Lacanau and Carcans.

The valley, which according to the theory ought to be produced laterally, exists along many of these defilading palisades. I have seen some of them very accentuated, notably one near Mimizan, which has cut across the dune of Arrouilles.

Lastly, it has often been found necessary to defend plantations against the sand carried from certain almost bare flats. This is the case between the basin of Arcachon and Lacanau, where a hundred or so dunes are isolated like islands in an immense flat. But these sands are no great danger; a wicker fence has sufficed [to stop them]. Such is the origin, for example, of small embankments, 1 metre in height, in the flat, at the foot of several dunes in the Commune of Arès, which puzzled me greatly when I first saw them.

The area of the works has varied much. Some are a few tens of hectares. On the other hand, the later works, when the Sovereign had personally insisted that all should be finished with the least possible delay, have very large areas. The works called Mimizan - St. Julian (1860) is spread over 2,159 hectares belonging to a single tenant, and must have cost, according to the scheme, about 313,000 francs.

The construction of works of any importance lasts several years—four years, for example.



Plan II.—Biscarrosse Works.

The short hatchings show the boundary of the works. The long parallel hatchings indicate *lettes*.

Palisades.	Length.	Palisades.	Length.
AB	3,415 m.	HI	585 m.
BC	1,650 m.	KL	515 m.
DE	400 m.	MA	1,065 m.

EXECUTION OF WORKS.

We will now explain in detail the proceedings involved in the execution of fixations. I shall take as example what has been done at the Lacanau works, but I shall complete with information obtained from other files.

I shall quote some of the expenses. All depend, either totally or for the greater part, on the cost of manual labour. I ought therefore to show the cost of manual labour. At the Lacanau works it is worth, by the day,—

	Fr.	c.
A brushwood-cutter	2	00
A woman employed in laying out, a woman employed in wickerwork	1	00
A boy employed in sanding	0	75
An ox-wagon, with driver	8	00
Two horses, with driver	6	00
	17	75

(17 fr. 75 c. = 14s. 2d.)

The cost of labour is now higher, and consequently the amount for fixation works which I have just shown would be insufficient. The contractor made a reduction, but only of 3 per cent. I have not taken account of that.

SOWING DOWN IN PINE.

The draft of our Lacanau works contains the following clauses:—

"The sowing for each hectare of dune will be done with 20 kilograms of pine-seed and 8 kilograms broom-seed, and 5 kilograms of marram-grass seed are to be added when the dunes are very unstable and exposed to breezes from the sea.

"These quantities of seed are to be spread separately and quite uniformly, and immediately covered over with brushwood to prevent their being blown together or scattered by the wind."

The pine in question is the maritime pine, *Pinus pinaster* (Soland.), *maritima* (Poir). The broom is the brush-broom, *Sarothamnus scoparius* (Koch). The marram-grass is the *Ammophila (Psamma) arenaria* (Link.). Gorse-seed is often added—European gorse, *Ulex europaeus* (Lin.). All these plants are indigenous to the country and flourish there remarkably well.

The quantity of different seeds per hectare has varied according to the works, the period, and the Engineers concerned. I shall quote merely a few cases:—

At the Biscarrosse works they used—Pine-seed, 18 kilos; broom-seed, 6 kilos; marram-grass, 4 kilos.

Goury, at the works near St. Eulalie, 1829, prescribed—Pine-seed, 16 kilos; broom or gorse, 4 kilos; hay, 5 kilos; heath, 2 kilos. (The addition of heath and hay is rarely seen.)

Le Boullenger, according to his report of 1817, used, per hectare, 30 kilos pine-seed and 10 of broom, or a total of 40 kilos, which exceeds the weight generally approved.

Some sowings of acorns have been made: Crouzet did so in 1847 on 50 hectares of the dune of Pignude, at St. Girons. But these trials have not been satisfactory, and have remained the only ones. The broom, universally utilized, has done badly at the Cape of Verdon and at

Cape Ferret, exposed on two sides to the tempests: it has been necessary in places to sow on these capes nothing but marram-grass. The broom has suffered, from the commencement of its growth, in certain dunes of the Bayonne region, where the sand is coarse, and consequently dries to a great depth in summer.

The pine in its first growth is at the mercy of the wind and the sun. The other plants protect it, especially the broom, which soon forms a thick scrub.

The addition of different seeds, amongst them the broom, was proposed by de Villers before Brémontier. But de Villers was careful to explain that these plants had for their object the stopping of the sand, whilst, according to Brémontier and his successors, their sole object in the process of fixation is to protect the very young pines. It is maintained that this mixture was first made by Peyiehan, Brémontier's local agent, on his own initiative, without having received an order to do so, but it is not known by what idea he was guided.

At the Lacanau works the cost of this sowing is the following, per hectare:—

	Fr.	c.
20 kilos pine-seed, at 35 centimes, including labour	7	00
8 kilos broom-seed, at 70 c., including labour ...	5	60
5 kilos marram-grass seed, at 20 c., including labour	1	00
Total cost of sowing, per hectare ...	13	60
(13 fr. 60 c. = about 10s. 11d.)		
Three-twentieths for incidental expenses and perquisites of the contractor	2	04
Cost of sowing 1 hectare	15	64
(Or, in round numbers, 15 fr. 60 c. = 12s. 6d.)		

No means are adopted at these works to cover the seed with sand, the trampling of the workers and the sanding (*sablage*), which will be spoken of later, sufficing.

Sowing in Marram-grass (Ammophila arenaria).

Marram-grass seed alone is used on the borders, which the defence works will not completely shelter from the outside sands.

The hectare of dune to be planted with marram-grass will be sown with 15 kilos of seed of this plant, mixed with damp sand so that it may not be carried away by the wind when sown broadcast.

	Fr.	c.
15 kilos marram-grass seed, at 20 c. a kilo, labour included	3	00
Three-twentieths, incidental expenses and perquisites of contractor	0	45
Cost of sowing 1 hectare	3	45
(Or, in round numbers, 3 fr. 40 c. = 2s. 8d.)		

The marram-grass thrives in the bare, moving sand. It was therefore planned to sow a strip 50 metres wide along the palisades on the inner side of the works, this strip being inevitably, by reason of these defences, liable to the attacks of the sand. Likewise, the part of the dunes situated at least 500 metres from the sea has been sown. Marram-grass, in fact, can alone do well there. All these sowings of marram-grass have been protected by a half-covering (*demi-couverture*)—that is to say, covered by a reduced quantity of branches.

Marram-grass grows of its own accord, in places, far from the sea. Le Boullenger, in his curious report of 1817, relates that having climbed, near Biscarrosse, to the summit of the high dunes of Dortiguet (at 4 kilometres from the sea), he found it crowned by a cone covered with marram-grass.

Flats (Lettes).

At this works the western slope of several dunes was skirted by a sandy flat. It was covered for a certain width with a half-covering, and that sufficed to enable the flat to plant itself with vegetation enough to fix it.

The scheme of the Biscarrosse works does not provide for covering being put on the flats, but for a transplanting on them. This operation consists in sowing (on the flats) 6 kilos per hectare of pine-seed, planted in holes 0·10 m. in depth, 0·25 m. apart, with about two seeds to the hole. This is estimated (seed included) at 12 francs per hectare. The object in view is less to fix the flats than to stock them with pines. Similar "transplanting" is also often done on sown parts of dunes that have come on badly. "Experience has shown," wrote Ritter in 1862, "that the mere fact of the neighbouring dunes being sown is sufficient to lead immediately to the natural establishment of plants on flats situated under the wind." However, in order to have there in good time a forest of pines it is necessary to plant the seed of that tree.

Time of Sowing.

"Sowing can be done at all times of the year if that is considered necessary in order to expend credits (within given time), but it is preferable to work as much as possible from the 1st October to the 30th April."

Slope at "Wall of Encroachment."

"Nevertheless sowing should not be done on the steep slopes of declivities except during the summer, when the sand is perfectly dry, and care must be taken besides to have it well stamped down by the workers, in order to lengthen the slope and to prevent the new sand, carried by the wind, rolling down and carrying away the covering."

This requires some explanation. We have seen that the greater part of the dunes requiring fixation are "dune-waves"; that the eastern slope, or slope of encroachment, of this kind of dune is very steep; that the damp sand, driven by tempests, accumulates above the "wall of encroachment" in a particularly steep slope; that it falls in sheets; that the sand of this slope, drying in summer, flows [down] less steeply. Consequently sowing done on this slope in winter or spring time must oll-down if special precautions have not been taken. On this subject eschamps junior wrote in 1840:—

"It is possible to sow immediately even the steepest backs of dunes ithout having to fear extraordinary loss. The method of doing so has ften been in use at the works of Soulac, Gravan, and Hourtin, and it s always succeeded. It consists in placing a dozen women and children the foot of the dune on the eastern side, and getting them to climb, d to stamp with their feet, the abrupt face that it is wished to fix. is repeated movement of the feet is enough to make the sand which is not settled on the face run down, and the *couverture* can then be spread without having to fear [the necessity for] large repairs. A team of twelve or fifteen women and children can in this way in half a day consolidate the eastern slope of a dune, an area of more than 100 hectares, with the very slightest increase of expense. If instead of immediately placing the whole of the dune under a covering of brushwood (the *couverture*) the eastern slope is left in a state of unstable sand, the winds of the north and north-east, which blow sometimes with much violence, tear up the sand on the edge of the sown area on the west and occasion the loss of several hectares. This was experienced by the Contractor Dumora at the Lacanau works,* where he had so left without *couverture* during the winter the eastern slope of one of the dunes that he had to fix. The repairs he had to make at the expiry of a few months proved there was no economy in following this system."

Jémois wrote on the 30th May, 1820:—

"I visited the sown area of Carquebin and Lestrounques, which I found finished and in good condition, with the exception of the crest of the slope of Lestrounques, and part of that of Carquebin, which had fallen down for about 400 metres, the height being reduced by about 10 metres. This kind of losses often happens at other works, but not so generally as upon this one. It must result if the precaution is not taken to make the sand roll down from the crest before placing the *couverture*."

COVERING *(COUVERTURE)*.

"Seed will be covered by boughs trimmed fanwise like the branchlets of trees on opposite branches. To this end all twigs above or below which would prevent the branch lying quite flat on the soil are to be cut off with a sharp instrument. If the rib of a branch is crooked or twisted, it is to be remedied before using by notches cut half-way through it with a very sharp instrument. These branches will be laid as exactly as possible on the surface of the soil, superimposed one on the other like feathers on a bird's body. [According to another method the boughs should be covered by the tops of the succeeding ones for a third or fourth of their length.] This covering to be kept on the soil by shovelfuls of sand thrown about 0·25 m. apart. [This is sanding.]

"On steep slopes, as the brushwood cannot be weighted down with sand, it is trimmed and overlapped, as has just been described, and, further, the thick end of the stem is forced into the soil to a depth of 0·10 m.

"1,500 bundles of brushwood, weighing 10 kilos each, are used per hectare on dunes to be sown in pine and broom, and 750 bundles only [*demi-couverture*] for parts to be sown in marram-grass, or for the fixation, without sowing, of sandy flats.

"The branches which form the bundles should not be more than 0·03 m. in diameter of the stem, and should have all their leaves. They should be cut for at least twenty days [before using] from the 1st November to the 1st April, and for ten days during the rest of the year."

These twenty days and ten days are prescribed to give the branches time to dry, because, generally, the bundles are bought by weight.

The procedure to be followed in laying the *couverture* is governed by the principle that we have already seen in regard to palisades. It was defined by Deschamps junior in 1833, consequent on a fortuitous incident he had observed at the dune of La Brisquette at Hourtin :—

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* It is another works, also in the Commune of Lacanau, which serves as an example.

"Let *abcd* (fig. 6) be a dune to be fixed. Let us suppose that it is isolated towards the north, and towards the south connected with a continuous chain. The sowing, and therefore the *couverture*, must go from north to south, to form, as near as possible, zones parallel to the direction of the south-west wind, taking particular care to establish [set] the lines of *couverture* in the same direction. If, on the contrary, the dune were isolated towards the south it would be necessary to begin the sowing in this direction, and to give to the zones of *couverture* a direction parallel to the north-west."

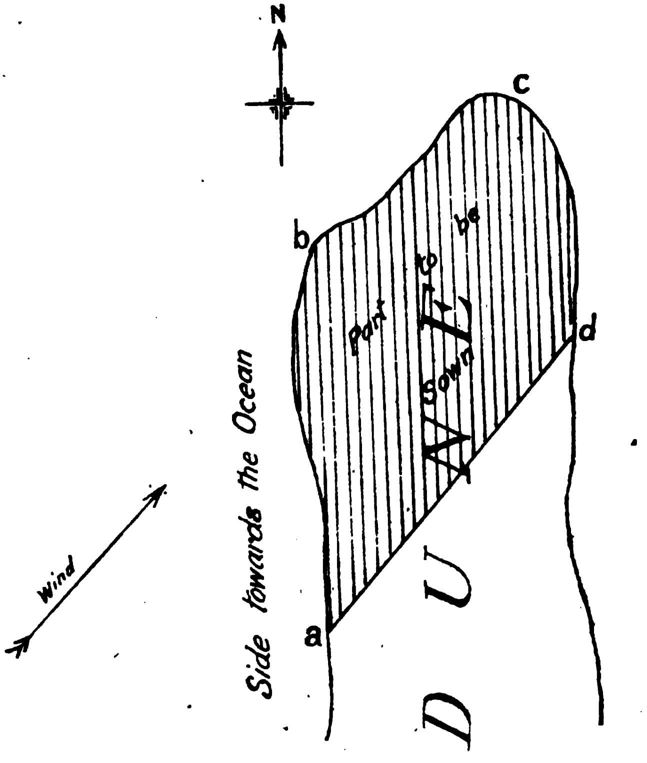

FIG. 6.—Orientation adopted for the covering. (The parallel zones are hatched.)

The plan of our Lacanau works does not show in what direction the branches, taken individually, ought to be placed; but another plan, laid down in 1846 by the same Engineer, Pairier, says, after giving the same course to be followed, "The stems of the branches should be placed in the direction of these zones."

In a plan of 1843, Chambrelent, after having prescribed the same procedure, adds that the stems of the branches ought to be placed in the direction of north to south. I think that this disposition of the branches should allow each zone to be begun easily at its seaward extremity.

In 1842 de Champflorin, at the works of Biscarrosse South, began at the southern extremity, proceeding N.W. to S.E. by zones about 3,500 metres long and 500 metres wide. He placed the *couverture* on each zone, beginning on the ocean side with, if I have understood aright, branches placed individually in the direction of south to north.

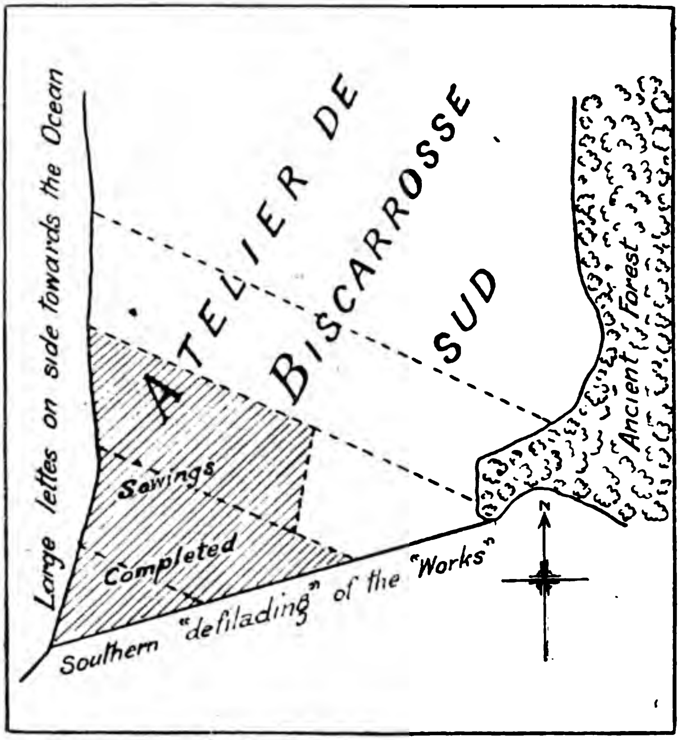
Large lettes on side towards the Ocean
ATELIER DE BISCARROSSE SUD
Sawings
Completed
Southern "defilading" of the "Works"
Ancient Forest
N

FIG. 7.—Procedure followed at the works, Biscarrosse South.

The above sketch, which he made in June, 1842, indicates this procedure, as well as the state of the works at that date.

Other modes of procedure have been adopted, but, with rare exceptions, they belong to earlier times.

In Landes, Goury in 1829, de Silguy in 1834, divided the surface to be fixed into zones 10 metres wide, parallel with the sea—that is to say, running from north to south. They commenced by the most westerly zone. They placed the tops of the branches to the east and the ends to the west, and arranged them thus in successive rows, beginning at the eastern edge of the zone, extending towards the west. Each row overlapped the preceding one by a third or a quarter. This first zone finished, they completed in the same way the one bordering it upon the east.

In 1819 Jémois, an Engineer of Landes, went to Gironde to study for his own edification the works (*travaux*) of La Teste, the perfection of which is renowned. He visited one of the works (*atelier*), then wrote :—

"We were astonished to see that the stems [of branches] were placed against [the course of] the prevailing winds, instead of going with them, as the theory recommends. Experience proves that in this way the wind do less harm to the *couverture* and that the branches are not di arranged. The stems of the boughs being placed in the direction of the wind, small crevasses are formed between them, the tiny pines are laid bare and often perish, the sand is carried forward on the *couverture*, &c.

"A comparison of the condition of the areas sown at the same time in Landes and at La Teste by the two methods induced us to give the preference to the method followed at the latter place."

But, whatever the solution adopted, it is very important that the branches be well placed close to the soil, or they will be carried away by the wind.

The branches (called also brushwood, heather, fagots, boughs) are of broom or gorse; then come, of second quality, pine and giant heather. The pine, perhaps on account of its threadlike leaves, allows the young plants to be grievously scorched by the sun. Giant heather decays too rapidly. Such is the order extolled by Saint Aubin, Deschamps junior, and de Silguy, in 1822, 1833, 1834. But the most recent plans do not give any preference.

Sometimes they are content with herbs or reeds spread with a pitchfork and weighted down by sand spread with a shovel.

The branches were taken, without having to pay cost or indemnity, from State lands or, in some cases, from commons.

Following is the cost of fixation of a hectare of the Lacanau works:—

Entire Couverture, *composed of 1,500 Fagots.*

	Fr.	c
Cutting of 1,500 fagots, 10 kilos weight, at 1 fr. 20 c. the hundred	18	00
Gathering and tying, at 40 c. per 100 fagots...	6	00
Transport	45	00
Spreading and sanding brushwood contained in the 1,500 fagots, at 1 fr. per 100 fagots	15	00
Total	84	00
(84 fr. 60 c. = £3 7s. 3d.)		
Three-twentieths for out-of-pocket expenses and perquisites of the contractor	12	60
Price of covering 1 hectare	96	60
(96 fr. 60 c. = £3 17s. 3d.)		

Sowing in pine costing 15 fr. 60 c., as we have seen, the fixation of the dunes, comprising sowing in pine and *couverture*, costs, per hectare, at this works 112 fr. 20 c. = £4 9s. 9d.

Demi-couverture, *composed of 750 Fagots.*

	Fr.	c.
Cutting, gathering, tying, and transport of 750 fagots (half of the cost above)	34	50
Spreading and sanding, at 1 fr. 15 c. for 100 fagots	8	62
Total	43	12
(43 fr. 12 c. = £1 14s. 6d.)		
Three-twentieths for out-of-pocket expenses and perquisites of contractor	6	47
Cost of *demi-couverture* of 1 hectare	49	59
(Or, in round numbers, 49 fr. 60 c. = £1 19s. 8d.)		

Sowing in marram-grass being estimated at 3 fr. 40 c. the hectare, fixation of 1 hectare in marram-grass, with *demi-couverture*, comes to 53 fr.

Couverture is the biggest factor in the cost of fixation, on account particularly of the transport of the brushwood of which it is composed.

We observe that in the cost given above (112 fr. 20 c.) of this fixation, transport of brushwood is entered at 45 fr., or rather 51 fr. 75 c., for it is necessary for this comparison to increase it by the three-twentieths. Transport therefore accounts for very nearly half the expense.

At certain parts of the Biscarrosse works fixation, including sowing, is estimated in the specifications at a cost of 198 fr. the hectare, of which 126 fr.—nearly two-thirds—are absorbed by transport of brushwood.

The carriage of brushwood has therefore played a very important role in every question of fixation of our dunes. One work has been designed with a poor surface because there was but little brushwood in the vicinity on the dunes or *lettes*. Another dune has been fixed in preference because advantage could be taken of a neighbouring dune, fixed eight years before, being covered with splendid brushwood which it would be a pity not to make use of. Often a dune has been fixed not for its own importance, but because in six to ten years it would be possible to use brushwood growing on it to fix others, the progress of which it was very necessary to arrest.

"In the Commune of Biscarrosse," said Ritter in 1851, "there extends a mass of dunes 10 kilometres long. In the midst of this mass since 1840 a surface has been sown of about 1,000 hectares in order to form a centre of production. . . ."

Similarly, in 1843, Chambrelent, at great expense, made two strips of sowing to divide the mass of mobile dunes, 50 kilometres long, lying between Lege and Hourtin, and to provide the means of attacking them some years later.

On the subject of an immense works of 2,159 hectares at Mimizan and St. Julien, with frontage of 6 kilometres to the sea, Ritter notes on the plan in 1860: "Being unable to subdivide them on account of the almost complete absence of flats, they surrounded it with plantations which to-day provide the resources necessary to attack it on three faces."

Looking at all our fixations of dunes with pine, one might say that in general their price per hectare, sowing included, has varied from a little less than 100 francs to a little more than 200 francs. But certain fixations effected at the time of the Commissions have cost much more: thus, at the outset, at Point de Grave and at Flamand (Hourtin), brushwood had to be sent for a distance of 18 to 20 kilometres, and the cost of 1 hectare of fixation exceeded 400 francs. Some years afterwards the brushwood from these two sowings enabled the neighbouring dunes to be fixed at a cost of 130 and 120 francs. The fact of the great distance had more than tripled the expense.

We have seen that the fixation of flats (*lettes*) has been, on the contrary, very cheap.

FIXATION BY PLANTATION OF MARRAM-GRASS (AMMOPHILA ARENARIA).

This method, which requires no *couverture*, but succeeds well o near the sea, where marram-grass can flourish, has been employed at t Biscarrosse works on a breadth of 170 metres along the littoral palisad The specifications of this works contain the following passages:—

"In plantations of marram-grass the bunches are to be disposed quincunx, 0·50 m. apart; use 300 bunches of marram-grass weighi 10 kilos each and 6 kilos of marram-grass seed.

"The marram-grass to be planted should be chosen from the finest and strongest tufts. . . . north of the Customhouse of Sanguinet. The average distance it has to be carried will be [in fact] 8,800 metres. Only such quantity [of tufts] should be pulled up each day as can be planted the same day or the next day. . . .

"As the bundles are made up they should be placed upright and covered with sand to a height of 0·25 m. to 0·30 m. in order to preserve the freshness of the roots. In placing them in the shed they should be treated in the same manner till the moment of using them.

"When getting ready to plant marram-grass, commence by throwing broadcast 6 kilos of seed per hectare. This will be covered over naturally by the trampling of the workers in planting the bunches.

"Each bunch to be planted should have at least five or six shoots. They should be placed in trenches 25 to 30 centimetres deep and 0·50 m. apart, arranged in quincunx and set round with sand well pressed down.

"The planting should be done for preference in the months of February and March" [August and September in the Southern Hemisphere].

FIXATION BY TUFTS OF BRANCHLETS.

Lefort (*l.c.*, p. 326) noted the origin of this method:—

"A trial of marram-grass made in the interior, in the Commune of Lit, did not succeed. However, although the bunches were dead all over the plantation, the sand was fixed and stable, whereas before the planting it had been always in motion. It was thought that for live bunches of marram-grass tufts of dead branchlets might be substituted to protect the seedlings. Trials were made in the Mimizan district, and they were a complete success."

This method, which was recommended by Goury about 1830, consists, instead of establishing the *couverture*, in planting vertically in the soil branches of broom, or, failing that, of giant heath or pine. The branches are 0·50 m. long, stuck in the sand 0·20 m., and planted thus in quincunx 0·50 m. the one group from the other. But this method, designed for the less exposed places, has succeeded only moderately well. Strongly opposed by Bilaudel, it has been replaced by the half-covering (*demi-couverture*), which gives a more certain result, without using more brushwood and at the same time necessitating less manual labour.

PALISADES.

The plan of the Lacanau works stipulates: "The palisades are to be formed of boards 0·03 m. thick, 1·60 m. high, and 0·15 m. to 0·25 m. broad. An interval between each of 0·02 m., driven in 0·60 m. These boards to be of tapped [for resin] pine."

According to Goury a space of 0·02 m. is left between each board " . . . in order that the sand may filter through the palisade and buttress it below in proportion as it is loaded on the windward side."

At the Biscarrosse works, where the palisades have a more important role, the boards are 1·80 m. long, and the specification adds: "The construction of palisades is done as follows: A trench is opened, 0·40 m. deep, in the bottom of which the boards, previously sharpened, are driven to a depth of 0·20 m., so that they are planted to a depth of 0·60 m. They are firmly fixed with the sand dug from the trench."

Very often the palisades are levelled by the wind or buried, "crowned" by the sand which they arrest. In the first case they are put up again, and in the second set higher. Goury thus describes how this raising is effected. The top of each plank is gripped by pincers with a long handle. A lever is passed through the ring of the handle and the plank is thus raised. The soil is then pressed down with the feet. Or the plank is bound round with a cord or chain through which a lever is passed. One end of the lever rests on the next plank and the [free] end is raised.

At all the works the setting-up of blown-down palisades and the raising of buried ones is paid for at the rate of, in the first case, 5 c. or 6 c.; in the other 10 c. These prices apply to the linear metre of palisade set up or raised.

The amount of this setting-up and raising has varied greatly. At the Biscarrosse works, the plan of which provides for 7,430 metres of palisades, comprising 3,415 metres along the sea, particularly exposed, it was foreseen that 20,000 metres of setting-up and 100,000 metres of raising would be required—that is an average of about three settings-up and thirteen raisings [per metre]. In fact, only 6,600 metres of settings-up and 47,000 metres of raisings have been done. The planks of the palisades were 1·80 m. long; others at the less exposed parts were 1·35 m. only.

The palisades were paid for, including material, at 1 franc to 2 francs the linear metre, according to the works, a cost which was much affected by transport.

CLAYONNAGES* AND CORDONS.

"The *clayonnages* are single or double [in height]: the first consist of a row of stakes 2·4 in. in mean diameter and 4 ft. 9 in. long, spaced 19 in. from centre to centre; they are driven 19 in. into the sand, and interwoven to the height of 3 ft. 3 in. above the ground.

"For double [in height] *clayonnages* the stakes are to be 8 ft. 2 in. long and 3·1 in. mean diameter; but the interlacing with branches at first is done to a height of only 3 ft. 3 in. above the ground, so as to leave an equal height for a second interlacing when the first becomes 'crowned' [with sand].

"The cordons of defence are to be formed of bundles of brushwood chosen 7¾ in. in diameter at the base and 27⅓ in. at least in height, planted in quincunx in two or three rows, according to circumstances, and driven 11¾ in. into the sand."

Cost per linear metre at this works: Single *clayonnages*, 1d.; double, 1$\frac{9}{10}$d.

At this same Lacanau works double *clayonnages* are planned instead of palisades at the boundaries of dunes which are little exposed to sand-drift; in other places, according to the plan.

"Single *clayonnages* interwoven for a height of only 1 ft. 7½ in. are to be constructed at the foot of the dunes at all points where the flats, at the time the planting is done, are sandy enough to cause encroachments."

THE LITTORAL DUNE.

We have seen that the Biscarrosse works stretch right to the beach, and that they had to be protected against the encroachment of sand by a palisade 3,735 yards long, the length of that side of the works. The accumulation of a great volume of sand has thus been produced which has built up a veritable dune—the littoral dune. In conformity with the plan *clayonnages* parallel to the palisade have been established. The design and the manner of proceeding are not indicated in the plan for this *clayonnage*, but they are explained in the works that I have cited of Grandjean and Bert. That Inspector and that Administrator of Forests were so much the better acquainted with it that the Forest Service was led to apply to the littoral dune all along the coast such considerable repairs as were equivalent to a reconstruction.

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* *Clayonnage* might be translated by "brushwood fence."

In order that this dune may not be damaged by the winds it is necessary that it should not exceed a certain height without being widened at the summit. In this design, on the dune APB (fig. 8), according to Grandjean, they have erected at 2 metres to the west of the palisade P a *clayonnage* C. Between these two defences bunches of brushwood were planted. The sand accumulates and the dune takes the outline DCPB. The palisade is then raised to P′, the *clayonnage* (C) is heightened by a second *clayonnage* (C′), and the intervening platform is consolidated by new bunches of brushwood; the result is a new outline IC′P′H. And these operations are repeated till the desired height is realized.

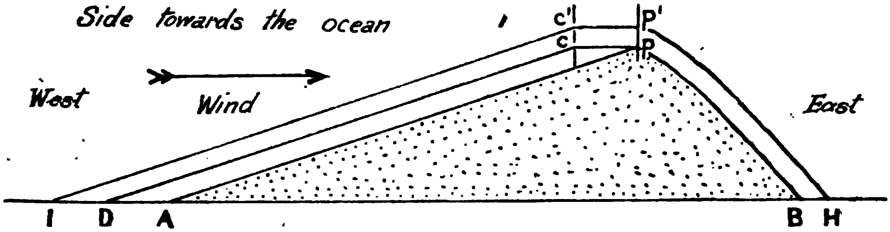

FIG. 8.—Cross-section of littoral dune.

Often they prepare a good width and a gentle slope in establishing, even at the beginning of the formation of a dune, a *clayonnage* (C), but placed at a greater distance from the palisade P, and (during this commencing period) without bunches of brushwood in the intervening space: this is probably the *clayonnage* of the Biscarrosse works.

The littoral dune is fixed with marram-grass by means of a plantation, or, failing plants, by sowing seed under covering at the rate of 33 lb. of seed per 2½ acres.

Grandjean considers that in order that it may suffer the least damage the littoral dune should not be made more than 32¾ ft. in height, and its slope towards the coast should be made gradual by means of brushwood to an inclination of 26 to 27 in the 100, but not more gradual.

If a breach is made by the wind in a littoral dune, it is checked and repaired by one or several cordons planted with plenty of marram-grass; or, indeed, the bottom of the breach is stocked with tufts of brushwood planted vertically. If in the course of time the wind forms a lump (called a *truc*) the marram-grass [on it] is pulled up and the surface loosened with a mattock, and the wind is not long in carrying it away. Irregularities [of surface] greatly favour attack by the wind.

In actual fact the littoral dune, when fully brought into a state of repair, has neither a palisade nor bunches of brushwood. It has only the *clayonnage*, as *c*, almost level with the ground, to mark the arrest. This dune is enormously widened towards the east.

Diverse Conditions.

The plan of the Lacanau works stipulates: "The contractor is responsible for success until three years after the last sowings have germinated. The annual examination is declared favourable to the contractor when the seeds have sprouted—during the first year, fifteen stalks of pine, and the same of broom, per square metre; the second year, ten stalks of each species; the third year, six stalks of each species. The surfaces of sown areas are measured horizontally, without taking into account the inclination of the slopes."

Documents on other files show that it is dangerous to suspend work for long: the sown area becomes buried in sand, the covering blown away, first from the borders, and later progressively from more of the surface. It is necessary, as Deschamps junior pointed out in 1833, to mark out the limits of the covering north and south according to the same principle as with palisades. It is also sometimes necessary to defend them by cordons. All damage should be repaired at once and palisades erected [where necessary]. Works abandoned in consequence of the calamitous political troubles in 1813 suffered great damage.

It is very important to prevent stock from pasturing [on the dunes]. Le Boullenger, in his report of 1817, even asserts, with some exaggeration, "It is probable that if the dunes were left to themselves, and not covered with numerous cattle which shave off and tear out all plant-life which grows there, the vegetation would soon get the upper hand, and overcome by degrees all the moving sands. The passage of stock alters the dunes in this way: their steps break down the demi-aggregation which binds the particles of sand and make it mobile to the force of the winds. Thus the dunes over which cattle daily pass become through that alone a depression, and soon a valley."*

In 1823 Saint-Aubin justly expressed the opinion that but for the cattle "many dunes would be fixed naturally, and nothing more would have to be done than to plant them with a shovel to get them covered with forest."

Since the commencement of fixation the wandering of cattle has been forbidden in sown areas and in their proximity, and likewise upon dunes that it is proposed to fix in a few years, and on flats destined to furnish covering-material. It is largely a question of cows and horses living in little groups in a wild state, and belonging to nobody. The rangers have orders to shoot these horses with their rifles. Even in 1839 a ranger of the Porge complains of "the havoc wrought by the wild horses this winter."

A crop of young pines, protected by thick brushwood, is very favourable to fires, but nevertheless outbreaks of fire have been very few during the fixation of the dunes. This is because, the country being uninhabited (because unproductive), there is almost no one who, wilfully or not, could start a fire. I have turned up in the files accounts of certain fires which were lighted by shepherds desiring to revenge themselves for prosecution for pasturing their flocks in sown grounds; accounts of other fires due t the carelessness of hunters; of others arising from the spread of fire kindled annually in the moor, east of the dunes, to renew the grass. Al these causes have been made the object of regulations for their suppressio or decrease. I add by way of an historical curiosity that on the 11t April, 1814, at the close of the war, an English troop of seven sailor came to Verdon to destroy by fire the dwelling of the chief of works and the cottage and stables of the contractor without any one knowing the reason.

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* In 1848 Conte-Grandchamps [considered that he] saw in that a way to excava roads across the dunes of Mimizan without incurring any expense.

RECKONING OF THE EXPENSE.

It appears to me that it would be interesting to close this examination of operations in detail by a reckoning of the expenses of the two works that I have taken throughout as examples. I have found only the expenses made in the contract. I am unaware as to what they have been (though certainly small) during administration.

LACANAU WORKS.

Reckoning of Work done by the Contractor, dated 24th November, 1869.

	Fr.	c.	Fr.	c.
340 hect. 53 ares sown in pine, broom, and marram-grass seed, at 15 fr. 60 c. per hectare	5,312	27		
86 hect. 18 ares 5 cent. sown with seed of marram-grass only, at 3 fr. 40 c. per hectare	293	3		
340 hect. 53 ares fixation with full covering, at 96 fr. 60 c. per hectare	32,895	20		
93 hect. 25 ares 60 cent. fixation with half-covering, at 49 fr. 60 c. per hectare ...	4,625	50		
			43,126	0
Defensive works :—				
325 linear metres double (in height) *clayonnages*, with stakes 2·5 m. long, at 19 fr. 50 c. per 100 m.	63	37		
424 linear metres of palisades, new planks, at 114 fr. 50 c. per 100 m.	485	48		
212 linear metres of palisade, made with planks taken from an old palisade of another works become useless, at 13 fr. 94 c. per 100 m.	29	55		
			578	40
Posts and stakes for laying out the works :—				
87 signposts of oak, at 3 fr. 20 c. each ...	278	40		
178 corner stakes of oak, at 1 fr. 30 c. each	231	40		
			509	80
Total	...		44,214	20
Deduct discount on contract at 3 per cent....	...		1,326	43
Cost *in toto* of work done	...		42,887	77

It is therefore seen that the protective works have cost relatively little —about a seventy-fifth.

BISCARROSSE WORKS.

eckoning of Work done by the Contractor, dated 15th October. 1860.

The price of 164 francs the hectare sown is an average price, appli-ble to the whole works. The contract gave the enormous rebate of 3 per cent.

This reckoning does not include a part of the palisades constructed of old boards taken from the defences of other works which had become useless by the juxtaposition of new works.

	Fr.	c.
645 hect. 10 ares 90 cent. sown and covered, at 164 fr. per hectare	105,797	88
62 hect. 51 ares 26 cent., plantation of marram-grass, at 92 fr. per hectare	5,751	16
9,219·85 m. *clayonnages* on stakes 2·50 m. long, at 30 c. per linear metre	2,765	95
12,263 metres *clayonnages* on stakes 1·50 m., at 25 c. per linear metre	3,065	75
5,828 metres new palisades (planks 1·80 m.), at 2 fr. per linear metre	11,656	00
9,668 raising of *clayonnages* by interweaving branches on their higher part, at 15 c. per linear metre	1,450	20
47,291 metres raising of sanded-up palisades, at 10 c. per linear metre	4,729	10
6,586 metres setting up blown-down palisades, at 5 c. per linear metre	329	30
273 metres new lower palisades (planks 1·35 m.), at 1 fr. 50 c. per linear metre	409	50
431 metres simple *clayonnages*, at 10 c. per linear metre ...	43	10
Total	135,997	94
Deduct discount of 33 per cent....	44,879	32
Sum total	91,118	62

It follows from this reckoning that out of 135,997 francs of total cost, discount (rebate) included, the defences (palisades, *clayonnages*) cost 24,448 francs, not counting the palisades made of old planks used again. This is almost a fifth, which is a considerable proportion, although the explanations that I have given made it to be expected.

VARIOUS QUESTIONS.

Economic Yield.

The authors of the fixation of the Gascony dunes considered, although as a secondary matter, the pecuniary advantage of transforming these sterile regions into productive territory. At present, thanks to them, these sands, formerly bare, are covered with magnificent pine forests which produce resin and timber in abundance. Do the receipts from these operations cover the cost?

Omitting those dunes and flats that have been restored to their ancient owners or alienated, the State now possesses 47,000 hectares (21,000 in Gironde and 26,000 in Landes), including in that area the littoral zone, which is not wooded and is unproductive. During the last four years (1910–13) this area has produced in timber, resin, &c., a return, varying but little, which on an average is something over 2,100,000 francs. On the other hand, the expenses of administration—the chief items being, of course, the work done and the wages of staff—are slightly above 300,000 francs per year. The net receipts are therefore 1,800,000 francs from 47,000 hectares—that is to say, on an average, 38 francs per hectare.

The total cost of fixation of the dunes and flats rises to thirteen millions (ten for the work of fixation and three for improvements) for an area of about 100,000 hectares. That is almost 130 francs per hectare.*

A revenue of 38 francs net resulting from an investment [outlay] of 130 francs represents an interest of 30 per cent. The enterprise therefore appears one of the most profitable. But it is necessary to remember that during very many years the capital, 130 francs, brought in nothing. It is thus that, for the part within the Department of Landes (26,000 hectares), the returns did not begin to cover the annual expenses until from 1895 forward, fifty years perhaps after the mean [average] date of the fixation. One must therefore admit that during this long interval, and for some years after, the capital invested has been much augmented, perhaps quintupled, by the effect of compound interest. The interest on the capital is thus brought down to one-fifth—that is, 6 per cent. The profit thus reduced is nevertheless very satisfactory, especially when it is considered that the work has put a stop to all the loss and damage that was constantly being caused to the inhabitants by the progression of the dunes.

Want of the means of transport has been mainly responsible for the length of time during which operations were not paying. During the past few years many railways have been constructed up to the dunes and passing through them, so that the question of transport is now entirely changed, and in the most advantageous way.

If means of transport had not developed more slowly than the productivity of the planted areas, the capital invested, increasing at compound interest, would have brought in 10 per cent.† But I must repeat that the calculations of interest that I have just made are, and can only be, approximate.

OWNERSHIP OF THE DUNES AND "LETTES."

The ownership of the dunes and *lettes*, which was of little importance and ill defined before the fixation when these regions were of no value, has since given rise to numerous disputes. Private persons and communes have claimed the ownership, either purely and simply, or in offering it to the State in settlement of the moneys expended by the Government under the Decree of 14th December, 1810. But the State has held that the State is the owner of the dunes, because, in fact, they have been produced by the sea. As regards the flats, the State also contended that they "are merely variations (*modalities*) of the dune created by the capricious progression of these moving mountains, which under the blast of the tempests now fill up these valleys, and now open them out again"; and in consequence a private individual or a commune "is unable to establish either possession or right of use necessary to obtain by prescription these estates which are borne hither and thither by the winds." Some ancient concessions have been interpreted rather according to modern law than according to that of the time at which they were made. On the whole the claims were not very successful.

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* It is probable that this expenditure does not include the whole of the cost of staff and general expenses. If this is so, the figures I have worked out require to be a little modified.

† I have found the greater part of the numbers which have served me for the basis of this economic note in de Lapasse's "Yield of Demesnial Maritime Pine Forests n the Dunes of the Landes" (*Revue des Eaux et Forêts* of the 1st June, 1906); also in ert, *l.c.*, pp. 109, 110.

In 1862 the Engineer Ritter proposed to covenant with the Commune of Sainte-Eulalie and others, which claimed the restitution of flats indispensable to their inhabitants for pasturing their stock. "If the communes," wrote he, "lost their case what would be the result? A general discontent and a hostility which might show itself even by the firing of plantations and the refusal of the people to assist in the case of forest fires." The Conservator of Forests feared "an ill will which might take shape in regrettable acts." The State agreed to covenant.

DRYING-UP RESULTING FROM THE NEW VEGETATION.

The great quantity of water which the foliage evaporates contributes to the drying-up of the country. One flat, formerly flooded at certain seasons, has not been so since sowing was begun. On the contrary, a few years ago all the pines on a wide stretch near Le Porge having been cut down, the vegetation of the marsh has reappeared in the hollows. I had this last fact from the Conservator Peloux, who had this forest in his charge.

TRACES OF OLD DEFENCES AT LA TESTE.

We have seen that the operations of Brémontier in the first period, 1787 till their suspension in 1793, had consisted in fixing the coast dunes in the environs of Moulleau. Brémontier thus prepared at a distance the defence of the large market town of La Teste, situated 4 kilometres due east, and greatly threatened. But under this system the defence could not be effective till the dunes on the whole of this width had been fixed. Therefore when the work was taken up in 1801 the direct defence of La Teste at Patchou, which is quite close, was at once decided on and commenced.

I was so fortunate as to find on the ground traces of this work and of other old defences of La Teste.

When from La Teste you go towards the west, in the plain across the fields and meadows at only 750 metres from the church, you come to a little wood of oaks, the King of Rome's Wood. It is the advance guard of a promontory of little dunes, wooded with pines—the promontory of Patchou. To the south, and separated from Patchou by a gulf-shaped space of meadows, is another promontory, that of Capet. To the north, and separated also from Patchou by a width of meadows, is the headland of Juge (see fig. 9). These three promontories are crossed or bordered by banks such as are produced by the palisades or wicker defences, AA', BB', CC', DD'. But I ought first to give some explanations.

The reader will remember the *flat dunes* and *dune-waves* or high dunes. Each of the two gulfs [of meadows] is terminated by a dune-wave—the dune of Capet and that of Laourey, which before their fixation (in 1813–14 the first, and 1815 the second) were slowly advancing towards the east, following their "wall of encroachment." But in the spaces between and at divers points on these dunes the sand is carried forward in flat dunes, and travelling along the ground. It is thus that our three headlands have been formed, veritable advance guards of the general overwhelming. At the headland of Patchou a rectilinear bank, BB', 2·50 m. high, 450 m. long, exactly marks the separation of the sown areas of 1807 to the east from those of 1813–14 to the west, just as shown on the general plan drawn up by the Department of Roads and Bridges: it is the bank produced by the *clayonnage* or palisade that defended the sowing of 1807 against the encroachment of the sands during those six or seven years, perhaps longer, if, as may be supposed from certain documents, this sowing was commenced much earlier.*

At the extremity of this same headland a rectilinear bank, 5 m. high, **AA′**, 250 m. long, separates the King of Rome's Wood from the pine wood dated 1807. Its volume by linear metre is nearly ten times that

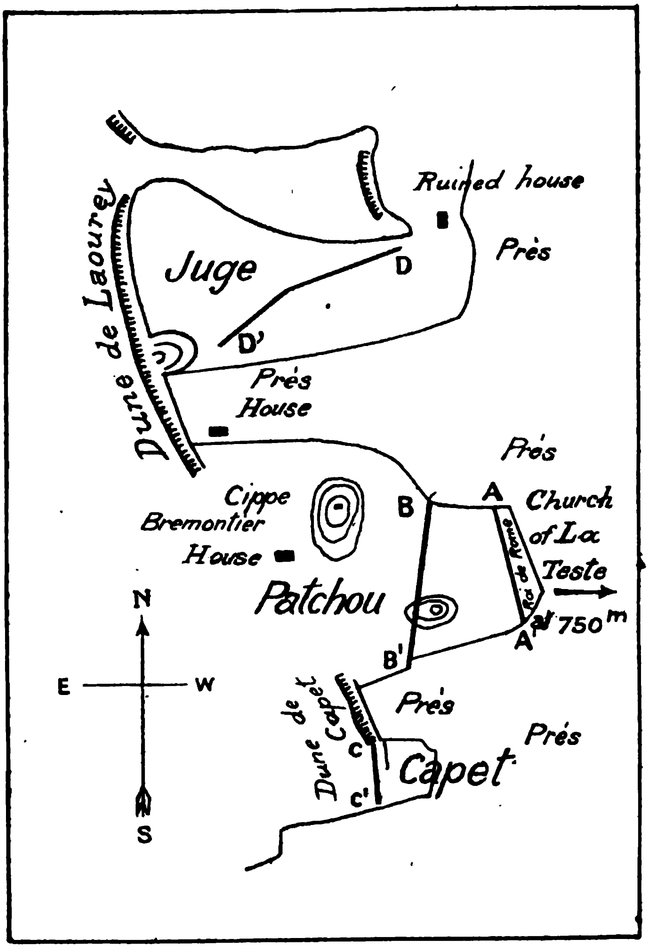

FIG. 9.—Plan of protection of La Teste.

f the bank BB′. This leads one to suppose that ten times the length f time, or sixty years, must have gone to the making of it; and as his line received no sand from 1807, if not earlier, it appears likely iat *clayonnages* were put there sixty years earlier, towards 1750—that is, forty years before Brémontier began. It is easy, on the spot, to calculate that if the sand had not been collected by this bank AA′ it would, in continuing its course, have lengthened the headland by from 200 m. to 300 m.: the encroaching sands would have been nearer to the church by one-third—they would have been but 500 m. away. The sand driven by the wind might have even come nearer to La Teste than we think, for all these headlands terminate in an extremely thin bed. Things must have happened as Le Boullenger elsewhere observed at Bias: "A dune that had penetrated into the heath had subdivided in a thousand ways, and had finished by scattering itself on the vast surface of the heath, the vegetation of which had fixed its light dust." One can understand the alarm of the inhabitants [of La Teste].

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* It is precisely towards 1807 that they began to employ palisades; up till then only *yonnages* were known. After some progress reports there were made at the headland Patchou in 1802 some important sowings, the success of which has been complete.

The less important headland of Capet, which was sown also in 1807, was created thus by the sands, thanks to a less steep slope at this point of the dune of Capet and to a little plain (C′). The bank of *clayonnage* or palisade CC′, 3 m. high, 150 m. long, occupies the crest of this dune, and in the direction C′ to the south traverses the little plain, separating thus, in perfect accord with the general plan of the Roads and Bridges Department, the sowing of 1807 from that of 1813–14 to the west.

The encroachment of Juge presents an interesting case: that of a flat dune produced by the dune of Laourey, and which, fed abundantly with sand, has developed in a long peninsula, and has taken on at its forward extremity the character of a dune-wave [high dune]. The oblique line DD′, which I have marked on the plan (fig. 9), to the south of this curious dune, indicates the site of an irregular bank, 2 m. high and 500 m. long, which is perhaps due to the *clayonnages*.

Catros, a member of the Commission, relates that in 1809 and 1814 he sowed on the headland of Patchou more than 25,000 red-pines and other conifers, and that almost all succeeded very well. I do not think I have seen more than eleven of them, sole descendants of those thousands (at the northern extremity of the King of Rome's Wood). At the commencement of the fixations trees of a great number of different species were planted everywhere, almost all of which grew well, and almost all of which have disappeared without leaving descendants. They disappeared owing to the competition of the maritime pine, the indigenous species (which from time immemorial has covered the ancient dunes); also owing to its economic competition, the maritime pine having this superiority: that it yields resin, which a few years ago was sold at 35 c. the litre, the same price as wine, and sold at 80 c. in 1864.*

There are on the modern dunes, and more so on their *lettes* [flats], some oaks of indigenous species.

We have seen that the first fixations of Brémontier, 1787–93, were made along the basin of Arcachon. They spread on either side of the clump of ancient forest at Moulleau. Have they left banks analogous to those of our three capes of La Teste? I have not been able to find out anything certain. At 650 m. or 700 m. from the central avenue of Moulleau the Sablonney Road crosses a dune 3 m. or 4 m. high, whi stretches perpendicularly to the basin for 550 m. Is this a bank pr duced by *clayonnages?* Is the higher dune of the same direction, whi bounds Moulleau on this side at 250 m. from the avenue, due also to the arrest of the sands by *clayonnages*, or is it due to their arrest by the first trees and shrubs of the old forest of Moulleau?

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* Present price (May, 1914) 28 c. The price of resin varies very much. It depen on the market price at Savannah (United States), the centre of a region which produc five times as much resin as Gascony. The advance in price of 1864 resulted from t check to this production consequent on the American War of Independence. [Tr lators' note: Evidently the Civil War is meant.]

FRENCH MEASURES, WEIGHTS, ETC., CONVERTED TO ENGLISH EQUIVALENTS.

1 metre equals 3·281 feet.
1 kilometre equals 1,093·63 yards.
1 hectare equals 2·47 acres.
1 kilogram equals 2·205 pounds avoirdupois.
1 franc equals 9·6 pence.
1 centime equals 0·096 penny.

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UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1430

Washington, D. C. ▼ August, 1926

FINANCIAL LIMITATION IN THE EMPLOYMENT OF FOREST COVER IN PROTECTING RESERVOIRS

By

W. W. ASHE, Assistant District Forester
Forest Service

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The influence of the forests in protecting reservoirs used for power purposes varies in different regions with the differences in soil, surface, and precipitation. In this bulletin those regions in which this influence is most important (pl. 1) are pointed out, also the value of forest cover and the financial limitations in its employment to prolong the utility of a reservoir are discussed.

POSSIBILITIES IN THE STORAGE OF STORM WATER FOR POWER

The development of water power in the United States has reached a point where hydroelectric engineers are no longer satisfied to use merely the minimum flow of a stream. Many power companies are now planning the storage of storm water or the spring and summer melt of snow.

The water-power resources of the United States can be greatly increased through storage of storm waters, it being estimated by

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[1] The writer desires to acknowledge the many valuable suggestions and criticisms given by Thorndyke Saville in connection with the preparation of this bulletin.

M. O. Leighton, of the United States Geological Survey, that with a minimum of 36,000,000 horsepower without storage there might with storage "eventually be established a total power installation of at least 200,000,000 horsepower and probably much more."

The minimum water-power resource of the eight southern Appalachian States, without storage, is placed by the United States Geological Survey at 3,340,000 horsepower. If storage of storm water is employed, this minimum can be increased, at a conservative estimate, to 5,678,000 horsepower. This increase is based upon the figures of the Geological Survey of Tennessee[2] indicating the possible increase in that State. Plans which have been worked out for the development of water power in Tennessee show that the power could be increased by storage 70 per cent above the minimum dry-season flow. Since the Tennessee River, on which these figures are based, is a large stream, its tributaries having their sources in six other States, it can reasonably be assumed that the water-power resources of the Appalachian and Piedmont regions as a whole might be increased in the same proportion.

A vast power plan which has been outlined by Harold C. Fiske for the full development of the Tennessee River calls for the construction of about 100 dams on the river above Knoxville. It is estimated that under this development there might be produced about 4,000,000 horsepower on the river at and above Muscle Shoals. The economic feasibility of this plan would depend largely upon the possibility of procuring at low prices much of the land which would be submerged by the reservoirs, many of which would be vast lakes.

This proposed plan may never be entirely consummated. In any event, if the enormous resource of this river at and above Muscle Shoals is to be adequately developed, it must be through a series of storage reservoirs, the ultimate value of which will depend upon the maintenance of storage capacity through reducing siltage.

NECESSITY OF PERMANENCY OF POWER RESERVOIRS

The value of a storage reservoir depends largely upon its life, that is, upon the permanency of its storage capacity. The rate at which erosion of soil is taking place on the basin of the supplying stream is the all-important factor in determining the period of service, or the number of years which will elapse before the soil removed by heavy rains from the lands on its catchment areas will fill the reservoir.[3] (Pl. 2, figs. 1 and 2.)

Many engineers, accepting siltage in certain regions as a natural condition, customarily determine the life of a reservoir and ascertain whether the earnings will provide for the amortization of its costs. There are regions, as will be pointed out, where methods for the control or reduction in silting are impossible or impracticable.

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[2] SWITZER, J. A. THE WATER POWERS OF TENNESSEE. Tenn. State Geol. Survey Bull. 17, 137 pp., illus., 1914.

[3] In most cases it is not possible to remove economically the silt deposited above the dam. To do so would often mean merely passing it to a reservoir lower down on the stream. It is suggested that the proposed Boulder Canyon Reservoir on the Colorado River be flushed, after draining it, once in about 10 years by means of a reservoir located above it and employed only for this purpose. It is doubtful, however, if this can actually be done since the river at present carries its full load of silt and the load could not be materially increased by flushing. There are likewise mechanical difficulties. But if such a system could ever be employed it might also be used most advantageously on the streams of middle and western Texas with their high silt burden.

The loss in investment, however, through the silting up of a storage reservoir on a head stream is trivial when compared with the actual loss to the region of the reservoir site; for when the storage capacity of a reservoir has once been destroyed the site can not be replaced. For this reason, it is of paramount importance that, wherever it is possible, the permanence of the reservoir be assured through adequate protection of the stream basins.

Just as the public is demanding that hydroelectric developments shall not be made piecemeal, but that they shall be so coordinated as to obtain the full and complete use of power possibilities, so it will require that the catchment area shall be protected from erosion as thoroughly as the physical conditions justify. This restriction would not apply to dams constructed largely to secure fall and not to provide storage, but only to such reservoirs as are located at or near headwaters and designed to provide storage, which will modify the regimen of the river, affecting its power possibilities and possibly its use for navigation, and tending to lessen floods.

It is believed that the same public conscience which now demands that the earning value of forest lands shall not be destroyed will also soon require the protection of reservoir basins, in the same manner perhaps as sanitation is now often provided for. Hydroelectric engineers and investors in water-power securities, as well as industries using hydroelectric power, should all be vitally interested in obtaining such protection to basins employed for water storage.

INFLUENCE OF FOREST PROTECTION ON SILTING

Excessive erosion in the forested parts of the United States is largely the result of unnatural conditions, and on many head streams it can be prevented or greatly reduced. Notwithstanding the fact that there are many reservoirs which have become so silted up that only the channel of the stream remains, this is not the natural condition for most streams the sources of which are within well-wooded regions; it is a condition produced very largely and often entirely through exposure of the naked soil—the removal of the protective cover of forest and of forest litter and humus. (Pl. 3, figs. 1 and 2.)

Though a number of reservoirs have silted flush except for the stream channel, these are chiefly on the smaller streams or where the solid burden contains a large proportion of coarse material. The reservoirs on larger streams where most of the material being transported consists of finer silt more easily held in suspension do not seem in all cases to silt flush, or they do so very slowly. There is a relatively rapid silting on the upper portions of the reservoirs. The silting then proceeds less rapidly until a stage is reached at which the rate of silting is materially reduced, either because eddies and convective currents hold matter in suspension or because velocity during floods scours the silt above a certain level. There are local features in nearly every reservoir which control the rate and the ultimate extent of deposit.

A matter for serious consideration also is the control which should be exercised by the States in preventing an increase in the solid burdens of streams in cases where such an increase would jeopard valuable power sites. In certain States large sums of money are spent by the Federal Government for channel dredging or for the purchase of woodland for the protection of stream flow, yet many States have taken no measures to check or control stream pollution. Enormous quantities of earth from mines, from washing kaolin, or from other sources are deposited in streams without protest. Thousands of acres of land too steep for permanent profitable cultivation are cleared, only to be abandoned, the subsequent erosion adding to the streams tons of silt, much of which is deposited, destroying reservoir space and increasing the cost of power or filling navigable channels. Later these deposits are removed at the expense of the general public, when a careful exercise by the State of its police power would have maintained the land in some form of permanent productivity, would have avoided much of the wasted effort in clearing it, and would have prevented the needless expenditure of public funds in the removal of silt beds from stream channels.

The western streams from Colorado and middle California northward which have their sources in the forested mountains are largely clear, or of prevailingly low turpidity, until they enter the treeless plains. Those which have their sources in and flow through the wooded regions of the Northeast are likewise clear. The headwaters of the Appalachian and southeastern Piedmont Rivers are clear and carry little silt burden so long as their watersheds are protected from erosion. Tallulah River in northeastern Georgia, on which are located two large storage reservoirs, is a typical stream of this kind. One of these reservoirs was recently emptied after 10 years of service, and when it was examined only a trace of sedimentation was found. There are, however, a few small clearings on the catchment area of this river. If such of these clearings as are hilly or have a rolling surface had not been cultivated, it is probable that even this trace of sedimentation would have been less. The North Fork of Swananoa River, from which the city of Asheville, N. C., obtains its supply of domestic water, has a very broken surface but is entirely forested. During very prolonged and heavy rains there is considerable turpidity, chiefly from leaching of vegetable matter, which is eliminated in a settling basin; at other times there is none. This small river is one of the head streams of the Tennessee River. The influence of the forest on soils subject to erosion is indicated by the difference between such head streams with forested basins and the Tennessee River in its lower reaches where it draws from similar soils unprotected by forest cover. So great is the silt burden of the main Tennessee River[4] that the pool above the dam at Hales Bar is reported[5] by the engineer in charge to have silted up in many places to the surface of the water, only the channel for the flow of the river remaining open.

Whether forests exercise any beneficial influence upon stream flow is beyond the scope of this bulletin. Certain hydrographers claim that they do not.[6] If the advocates of the protective values of for-

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[4] From data furnished by Herman Stabler, of the U. S. Geological Survey, it is computed that the Tennessee River, with a basin of 35,000 square miles, yearly transports nearly 11,000,000 tons of earth.

[5] MATTHES, GERARD H. TENNESSEE RIVER AND TRIBUTARIES, NORTH CAROLINA, TENNESSEE, ALABAMA, AND KENTUCKY. APPENDIX A. U. S. Congress, 67th, 2d sess., House Doc. 319, p. 110. 1922.

[6] It is the opinion of D. W. Mead that forests exert practically no influence upon stream flow in Wisconsin, and F. E. Frothingham has recently made the same statement regarding forest cover in relation to the streams of New England. FROTHINHAM, F. E. FORESTRY, HYDRO-ELECTRIC DEVELOPMENT, AND CONSERVATION. N. Y. Forestry, 9: 18–19. 1923. But Charles L. Potter, president, Mississippi River Commission, is inclined to the view,

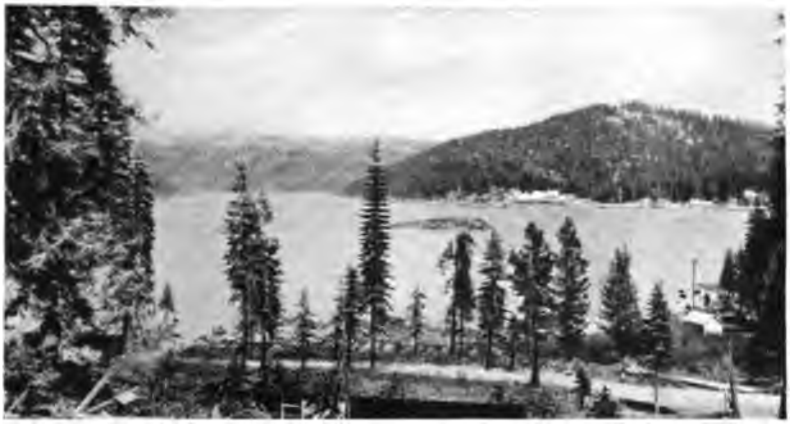


PHOTO BY F. E. BONNER

A REGION WHERE FORESTS HAVE HIGH PROTECTIVE VALUE

FIG. 1.—Huntington Lake, southern Sierras of California. Along the lower Sierras long periods without rain are broken by a short rainy season often marked by most concentrated precipitation. As a result ground cover is often thin or lacking. At Springville 42 inches of rain has fallen within a month. In seven consecutive months of the same year less than 2 inches fell. Similar concentrated precipitation is recorded at Summerdale, North Fork, Milo, Huntington Lake, Hot Springs, and other places in the southern Sierras

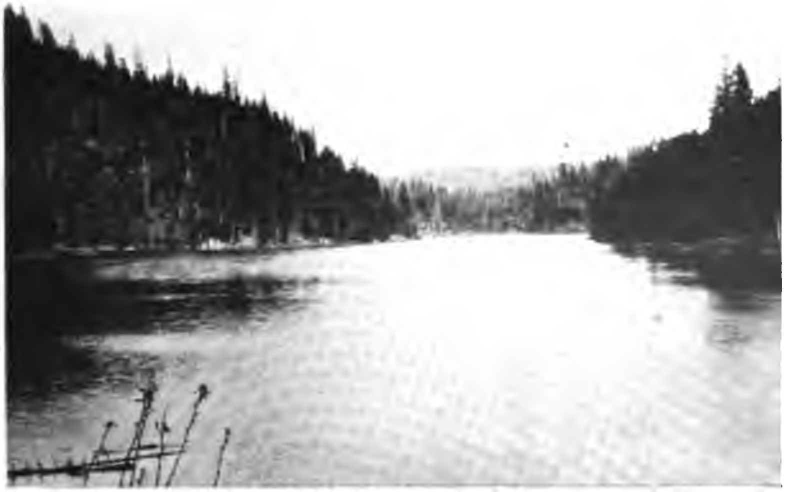


PHOTO BY FEDERAL POWER COMMISSION

HIGH VALUE OF FOREST COVER

FIG. 2.—Reservoir in Yuba County, Calif., on North Fork of Yuba River. A region of prevailingly low but often concentrated and irregular precipitation, and subject to destructive erosion of naked soil

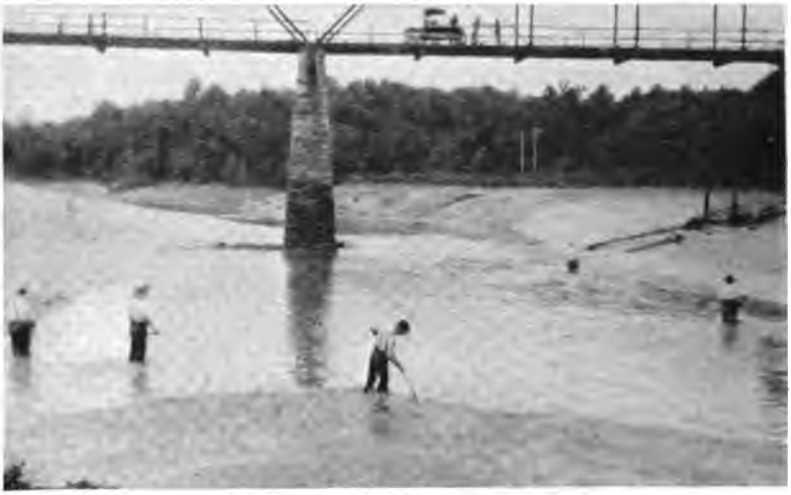


PHOTO BY THORNDYKE SAVILLE, N. C. GEOLOGICAL AND ECONOMIC SURVEY

REMOVING SILT FROM RESERVOIR

FIG. 1.—Reservoir on Deep River, N. C. Pondage so reduced by siltage that twice a year it is necessary to draw down the water to allow the silt to be removed in front of the wheel inlets

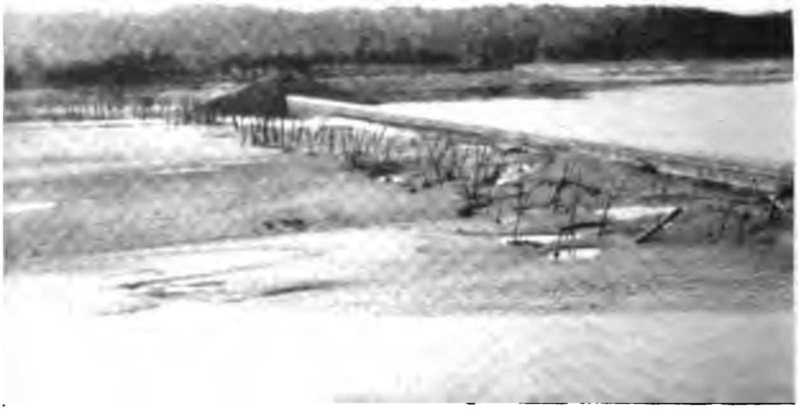


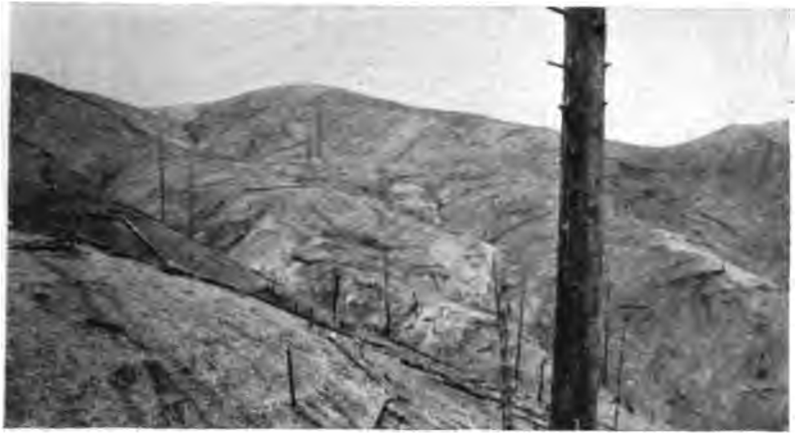
PHOTO BY THORNDYKE SAVILLE, N. C. GEOLOGICAL AND ECONOMIC SURVEY

PONDAGE DESTROYED BY SILTAGE

FIG. 2.—Looking downstream at Whitney Dam, above Badin, N. C., on Yadkin River. Water drawn off, exposing silt beds nearly filling the reservoir and exposing only the upper portion of the 38-foot high dam, constructed in 1910. The water below the dam is back water from new dam 180 feet high which floods the old

HOW EROSION OF SOIL INCREASES THE COST OF POWER

A reservoir which lasts only 25 years must be paid for within that time by the users of its power



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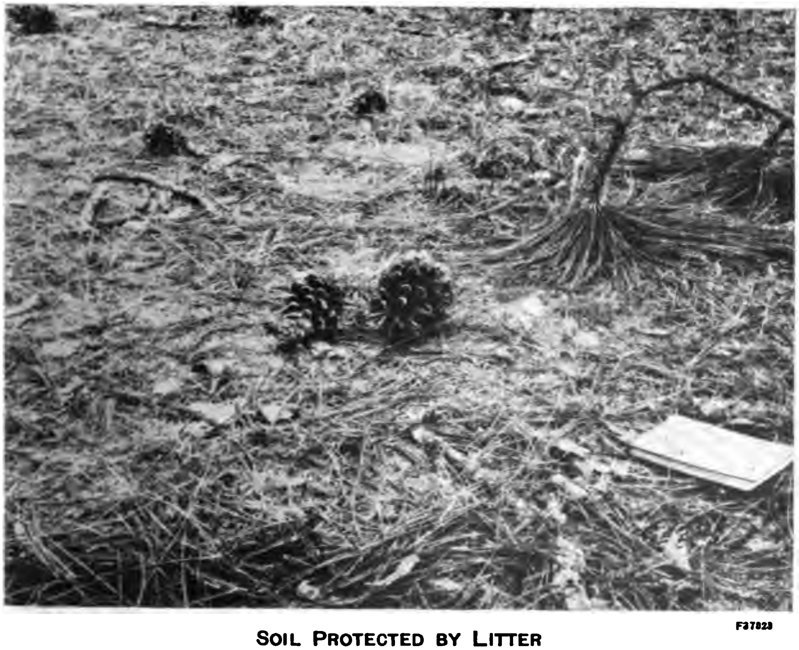
EROSION OF EARTH FOLLOWING DESTRUCTION OF VEGETATION

FIG. 1.—Forests destroyed by smelter fumes. The soil is unprotected and erosion is most destructive



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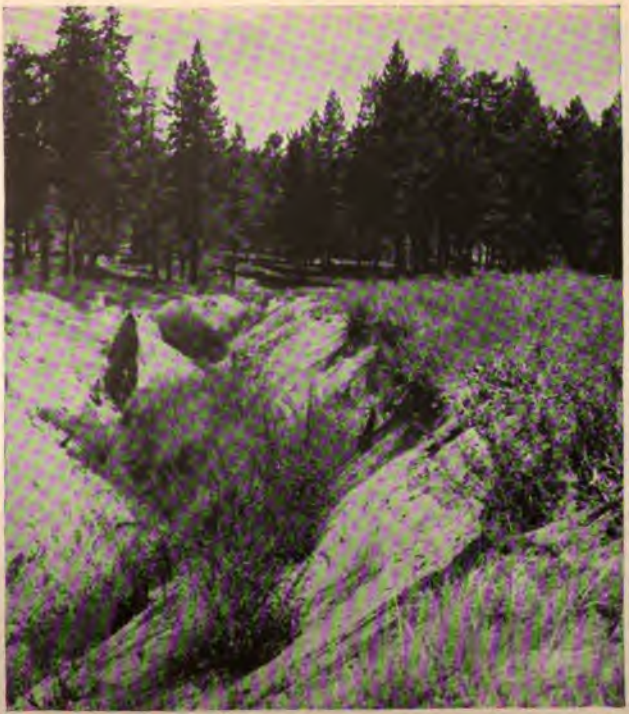
SOIL PROTECTED BY LITTER

FIG. 2.—The blanket of needles and litter beneath a dense pine wood is nature's thorough protection against erosion of soil

FOREST LITTER REDUCES EROSION OF SOIL



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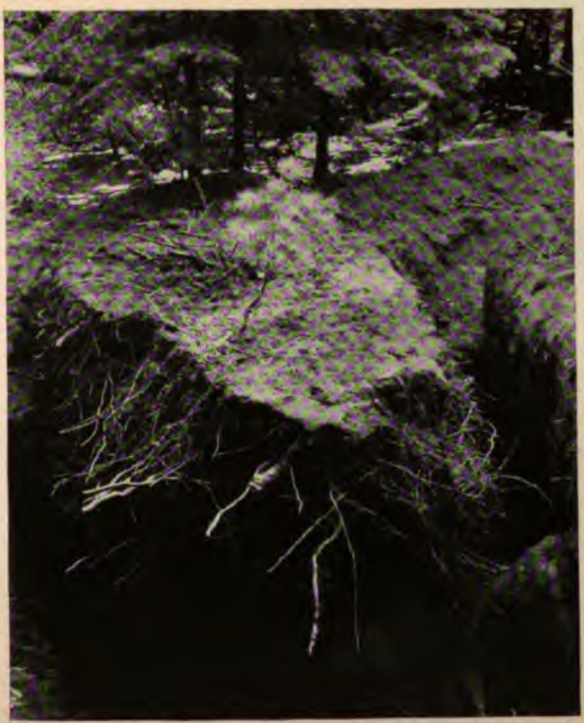
EROSION CHECKED BY WOODS

FIG. 1.—Deep gully extending up to the edge of yellow pine forest. The forest checked erosion. San Bernardino County, Calif.



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ROOTS OF TREES BINDING THE SOIL

FIG. 2.—Roots and rootlets of forest trees in the soil, showing how their network binds the soil and protects it from erosion. When a tree dies the soil and subsoil become filled with hundreds of small aqueducts where the roots were. This makes the earth permeable to a great depth

ests have generalized too much from particular cases, those who rely upon mechanical means of stream control have likewise drawn their conclusions from inadequate data and from a too restricted field. At any rate it will be shown that forests, under certain conditions, have a most significant influence in determining the permanence of the development of a stream—development which enables storm water to be stored for power purposes, which to a limited extent equalizes stream flow for navigation, and which under some conditions may be of material benefit in the control of floods.[7]

Even if it were conceded, as is claimed by Mead,[8] that forests have little influence upon stream flow and the development of water resources in northern Wisconsin, and in regions of similar sandy or glaciated soils, the situation would not be the same in other regions with different soil and climatic conditions. The protective influence of the forest is of great importance in most regions subject to excessive erosion when the naked soil is exposed. In the sandy soils of the Coastal Plain region of the Southern States, where the conditions are very similar to those in the Great Lakes Region, forest influences are prevailingly at a minimum and are often negligible,[9] but these influences increase in other regions, apparently reaching their maxima, as will be shown further on, in the Sierras of California, in the southern Appalachians, and in the southern Piedmont.

The discussion in this bulletin will be restricted to erosion, the sections of the United States where it is most prevalent, the conditions of rainfall, surface and soil which cause excessive erosion, and the means of reducing it for the protection of water-power resources.

SOURCES OF SOLID BURDEN OF STREAMS

The solid burden carried by streams is derived from several sources, summarized as follows:

Farming lands, especially such as are situated on steep slopes.

Woodland and brush land in which the soil cover of litter does not afford an adequate protection.

Grasslands, especially thinly stocked prairies and the plains of the Western and Southwestern States where the sod, or sod and brush, is not sufficiently dense to protect the soil and prevent erosion.

Earth roads subject to degradation, ditches along roads, and unprotected cuts and fills along railroads and highways.

Washings of ore and clay, mine water, etc., which in place of being retained in settling basins are disposed of in waterways.

Corrasion of banks of streams.

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which he supports by figures of run-off, that forests may have a limited influence, at the headwaters of the Mississippi River, in obstructing the run-off, and that brush land efficaciously performs the same function. POTTER, C. L. SOME SUGGESTED WAYS OF CONTROLLING THE MISSISSIPPI FLOODS. Engin. News-Rec., 94 : 558. 1925. The repository of arguments for and against the benefits of forests to stream flow is a paper by H. M. Chittenden, with its accompanying discussoin. CHITTENDEN, H. M. FORESTS AND RESERVOIRS IN THEIR RELATION TO STREAM FLOW, WITH PARTICULAR REFERENCE TO NAVIGABLE RIVERS. Amer. Soc. Civ. Engin. Trans., 62 : 245–318, illus. 1909. (Discussion, p. 319–546.) Unfortunately generalizations control most of the discussions. It is seldom that all the essential facts are given or that proper weight is given to different factors, and this is particularly the case in those portions of the discussion which refer to erosion of soil and corrasion of stream banks.

[7] See LEIGHTON, M. O. RELATION OF WATER CONSERVATION TO FLOOD PREVENTION AND NAVIGATION IN OHIO RIVER. *In* Preliminary Report of the [U. S.] Inland Waterways Commission. pp. 451–490. 1908. (U. S. Congress, 60th, 1st sess., Senate Doc. 325.) See also [PITTSBURGH. FLOOD COMMISSION.] REPORT OF FLOOD COMMISSION OF PITTSBURGH, PENNA. 252 pp., illus. [Pittsburgh. 1912.]

[8] MEAD. D. W. THE FLOW OF STREAMS AND THE FACTORS THAT MODIFY IT, WITH SPECIAL REFERENCE TO WISCONSIN CONDITIONS. Wis. Univ. Bul. 425 : 62. 1911. (Engin. Ser., v. 6, no. 5.)

[9] ASHE, W. W. FORESTS AND THE COST OF TEXTILE PRODUCTION. 11 pp. [n. p.] [1908.]

The factors which determine the erosion of naked soils are the character of the soil and subsoil, the gradient of the surface, and the amount and character of the rainfall or other precipitation. A soil which is thoroughly granulated, even if situated on a moderate slope, is not subject to erosion. Such soils are fine gravels and coarse sands and soils of finer texture which are granulated on the surface and have thorough subsoil drainage. Soils of finer texture having a deficiency in binding material, such as river silts, loess, or other silty soils, and in the East the well-decomposed micaceous schists, are subject to excessive erosion.

The character of the rainfall is also of importance. Slowly falling rain of large total volume may, through the time allowed for percolation into the subsoil, be largely absorbed, leaving only a small amount to find its way over the surface of the soil directly into drainage channels. A much smaller proportion of the same amount of precipitation would, if concentrated, be absorbed within the same time. The greater the amount which is not absorbed, the greater is the run-off over the surface, with accompanying erosion.

According to Kennedy,[10] the quantity of silt which can be carried in suspension by a stream varies according to the square root of the fifth power of its velocity—that is, the possible silt burden increases at a much higher rate than the velocity. In case the velocity of a stream is 2 miles an hour and it is increased during flood period to 4 miles an hour, the quantity of silt which it can carry increases six times. Consequently the capacity of a stream for carrying silt increases enormously during flood periods. Corrasion of banks or channel continues to take place until the maximum silt burden for the velocity is reached. When there is a slacking in velocity for any reason, as when there are pools, or when the stream spreads out over a flood plain, a portion of the silt is deposited. But before a particle is in suspension it must be freed from associated particles either upon the surface of the land, upon the stream bank, or at the bottom of the channel. As a rule a particle must become a part of a bed load before it passes into suspension. So erosion as a rule is determined initially by the capacity of a stream for bed load. The weight of bodies such as sand, gravel, or stone, which can be rolled along the bed of a stream, varies with the velocity of the current,[11]

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[10] KENNEDY, R. G. THE PREVENTION OF SILTING IN IRRIGATION CANALS. Inst. Civ. Eng. [England], Minutes Proc. (1894/95), 119: 281–290, illus. 1895. Kennedy's formula was based upon studies of canals. Studies upon Texas streams made by R. G. Hemphill, associate irrigation engineer of the Department of Agriculture, seem to show approximately the same percentage of silt, 1.3 by weight, being carried on the Brazos River at Waco by velocities which ranged from 0.69 up to 7.50 per second, and from the surface nearly to the bottom. The fineness and character of the silt is a factor. His investigations do not seem to bear out for Texas conditions Kennedy's statement "that corrasion continues to take place until the maximum silt burden for the velocity is secured." Undoubtedly considerable additional study of this problem is necessary.

[11] MERRIMAN, M., and MERRIMAN, T. TREATISE ON HYDRAULICS. Ed. 10, rev., pp. 294. 339. New York. 1916. According to Merriman the weight of bodies which can be rolled along the bed of a stream varies as the sixth power of the velocity of the current.

GILBERT, G. K. THE TRANSPORTATION OF DÉBRIS BY RUNNING WATER. U. S. Geol. Survey Prof. Paper 86: 10–11. 1914. Gilbert has given the subject thorough study in the laboratory, but states that the results of his investigations are to be regarded only as a contribution to the subject. In discussing the laws which control the movement of the bed load he makes the following general statement: The capacity of the stream to transport débris along its bed is affected by the width of the stream, a broad channel carrying more than a narrow one, by the velocity of the current, the quantity varying greatly for small changes in the velocity along the bed. Bed velocity is affected by slope and depth, increasing with each factor, and depth is affected by discharge and also by slope. The size of the transported particles is a factor of great importance, a greater weight of fine débris being carried than of coarse. But capacity of a stream to transport is less sensi-

and for each combination of width, slope, and discharge there is a limiting coarseness of débris above which no transportation takes place. The rate of flow increases with the volume or the depth of the water in the channel. These laws of flow and of the carrying capacity of water at different velocities of current explain the great amount of erosion of soil which takes place in regions of heavy or concentrated rainfall, such as the mountains of California, the Southwestern States, and the southern Appalachian and adjacent Piedmont regions, regions not only of concentrated rainfall, but of broken surface where it is possible for surface run-off to gather into rapid torrents having great volume and enormous cutting and carrying capacity.

The more thorough the cultivation of farming lands, the deeper the plowing, the more humus incorporated, and the better the granulation and the absorptive capacity of the soil, the lower will be the proportion of rainfall which runs off and the less will be the extent of the erosion. This is a matter of prime importance to the farmer as well as in connection with reducing the turbidity of streams, since, in addition to the physical destruction of land through the formation of gullies by erosion, the muddy effluent bears away the lighter and more fertile parts of the soil, resulting in its constant depletion. At the same time the loss of water which should soak in and be stored in the subsoil for future dry-season needs is often equally serious. Although agricultural lands contribute but a relatively inconsequential part of the total solid burden of most of our great rivers, except in the Southeast, on the whole the wastings from the agricultural lands represent the element of greatest fertility, the humus, the organic components, containing particularly the nitrogen or ammonia compounds. It has been computed[12] that an average of more than 850 pounds of soil are yearly washed from every acre of land on the Yadkin River above Salisbury, N. C. Of this more than 125 pounds are organic matter, the balance being mineral soil. The organic matter is humus, chiefly from farming soils, and where this is the case it must be replaced.

In woodland, erosion is due chiefly to the exposure of the soil through the destruction of the humus and leaf litter by fire or other agency. A forest soil as a rule has excellent subsoil drainage due to root penetration, and the top soil is usually well granulated. Moreover, there is a prevailingly good binder of rootlets. (Pl. 4, figs. 1 and 2.) For these reasons, even when the leaf litter is annually destroyed, erosion is seldom so disastrous as it is in the case of a soil used for farming, or which has been farmed and abandoned.

In open parklike woodland and brush land, such as exist in sections where the rainfall is not sufficient to support a dense stand of trees, as is particularly exemplified on the lower mountains of the West and Southwest, the litter and leaves which accumulate are not sufficient to cover the soil and afford it adequate protection. Under

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tive to changes in fineness of débris than to changes in discharge or slope. If slope remains the same velocity changing with discharge, capacity for transportation varies with the 3.2 power of the velocity. If discharge remains the same, in which case velocity changes with slope, capacity varies with the 4.0 power of the velocity. If depth remains the same, the velocity changing with simultaneous changes of slope and discharge, capacity varies with the 3.7 power of the velocity.

[12] ASHE, W. W. TERRACING OF FARM LANDS. N. C. Geol. and Econ. Survey Bul. 17: 22. 1908.

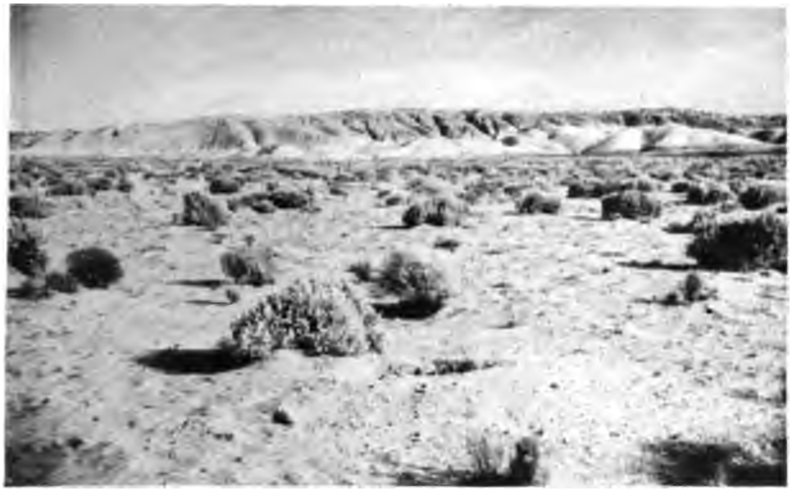
such conditions and with a concentrated rainfall, or with the rapid melting of snowfall, erosion is active. Since it is not possible to maintain in such sections forest or brush growth of sufficient density to produce adequate litter, it is not possible to reduce erosion of soil below a certain amount, the amount which is fixed by the heaviest litter which can be maintained. (Pl. 5, figs. 1 and 2.)

On the western plains there are extensive areas of unconsolidated soils protected only by a scant stand of grass, with scattered bushes intermixed. Notwithstanding that these lands are nearly level, erosion from them is often excessive. Where the grass cover has deteriorated through excessive grazing, a regulation of range practice may have the double beneficial influence of checking further range depletion, and at the same time, by inducing the more thorough covering of the soil, of lessening erosion. There are undoubtedly extensive areas in Texas and Oklahoma where this condition prevails.

Ditches along roads and cuts and fills along highways and railroads, especially in the Southeastern States where the rainfall is heavy and where grass does not readily set, contribute a large quantity of solid matter to the streams. By the use of Bermuda and carpet grasses in ditches, and these grasses and Japanese honeysuckle on embankments and slopes, much of the erosion from these sources could be prevented or at least greatly reduced. The rapidity with which erosion takes place in roads in the Piedmont and mountain sections of the Southeastern States is shown by the hundreds of miles of hollow roads in this section. A good example of road degradation through erosion is shown in Plate 6, Figure 2, and the deeply washed ditches on either side show the process by which it takes place. The brush in the ditch is the futile means employed to check it.

Friction between the current and the bank is a factor in the corrasion of banks of streams. Corrasion continually takes place, especially during periods of high water, whether resulting from rainfall or from melting snow. It is most active, however, in the streams flowing through the regions of the Great Plains. This results in shiftings of stream channels, which is particularly characteristic of the Missouri, the Arkansas, the Kansas, the Canadian, the Red River, and many of their tributaries. Corrasion is also not uncommon along many eastern streams. It is aggravated in instances by the clearing away from stream banks not only of all trees but of shrubs as well. Upon the decay of their roots the natural soil binder is destroyed. (Pl. 4, fig. 2.) The small roots and rootlets of willows, birches, alders, cane, and similar trees and shrubs grow to the very water's edge. They are often exposed along the banks of the stream and form a loose basketry often quite as effective in bank protection as ripraps.

In the aggregate the solid burden which is added to streams through the washings of ore, clay, etc., is not large in comparison with the turbidity which comes from other sources. Locally, it is of importance. This contamination of streams is sometimes permitted as a result of a sentiment opposed to interfering with the conduct of local industries. Waste of this kind which is deposited in streams must frequently be removed, often at public expense, from navigable channels or from reservoirs within which it has been deposited. In some States, as in California, there are restrictions against such pollution.



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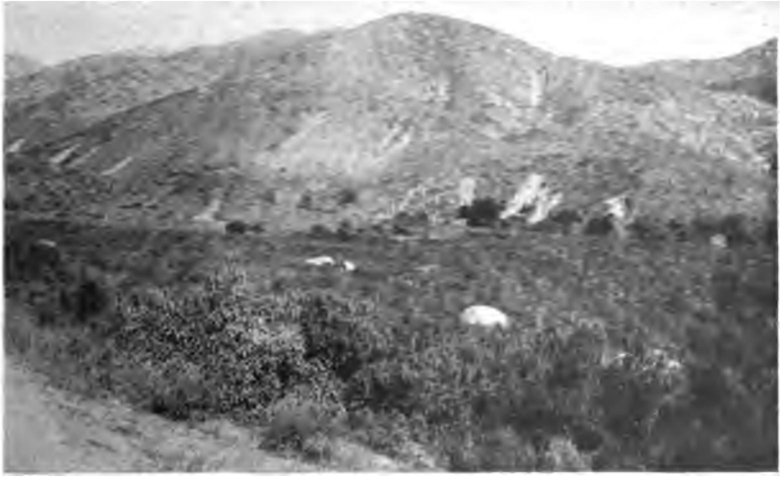
EROSION OF NAKED MOUNTAIN SLOPES

FIG. 1.—Naked mountains and plains, Apache County, Ariz.



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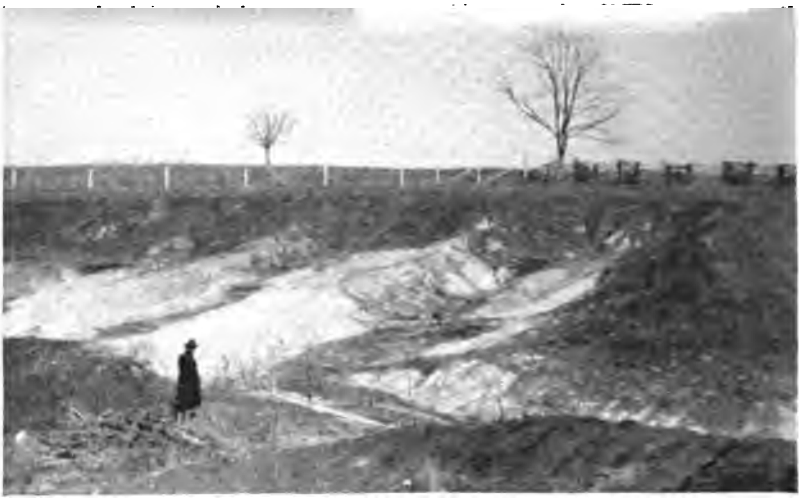
EROSION OF SCANTILY PROTECTED MOUNTAIN SLOPES

FIG. 2.—Gullied and eroded slopes, brush-covered mountains, San Diego County, Calif.

WHERE EROSION OF SOIL CAN NOT BE PREVENTED

Typical of much of the country of western Texas, New Mexico, Arizona, and parts of southern California. Long periods of drought limit vegetation to a scant herbage and hardy shrubs. Consequently much of the surface is exposed. At intervals there are torrential rains, and when these occur erosion is disastrous



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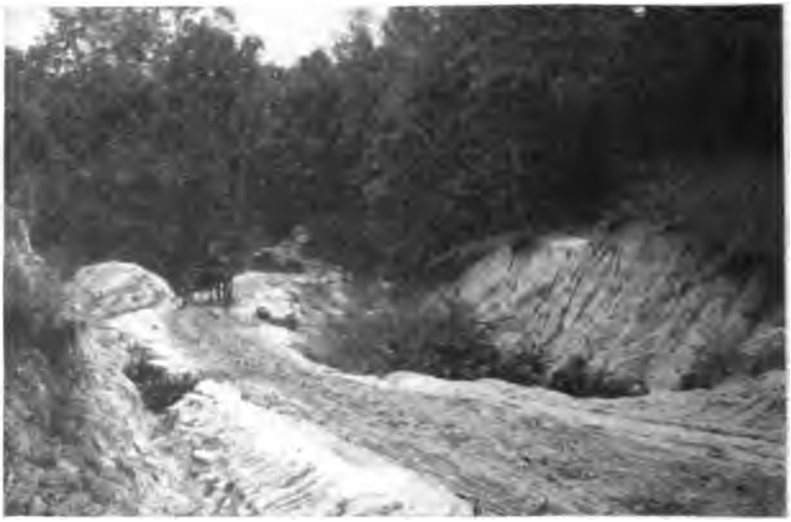
EROSION OF EARTH ON FARM

FIG. 1.—Badly eroded farming land, with brush dams across the gullies, the naked slopes planted to locust switches



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EROSION OF EARTH ALONG ROAD

FIG. 2.—Millions of tons of earth from the "hollow" roads of the South half choke the streams. Brush placed in a ditch, which through neglect has become a gully, in a futile effort to check washing away of the road

SOURCES OF SEDIMENT WHICH FILLS RESERVOIRS

If the life of a reservoir is 50 years, the users of power should pay for it in that period. If on account of erosion it is only 25 years, the annual payments must be twice as much

F30931A

INEFFECTIVE ATTEMPT AT PREVENTING EROSION

Masonry dams in the mountains of southern California designed to check torrents, reduce erosion of soil, and promote absorption of rainfall. Note scanty soil cover in places and erosion on slope where the soil cover is thin or wanting. Thirty-eight hundred of these dams have been built and the results show that the work has considerable value in promoting absorption of water on the level benches, but is largely futile in so far as reducing erosion on unprotected slopes

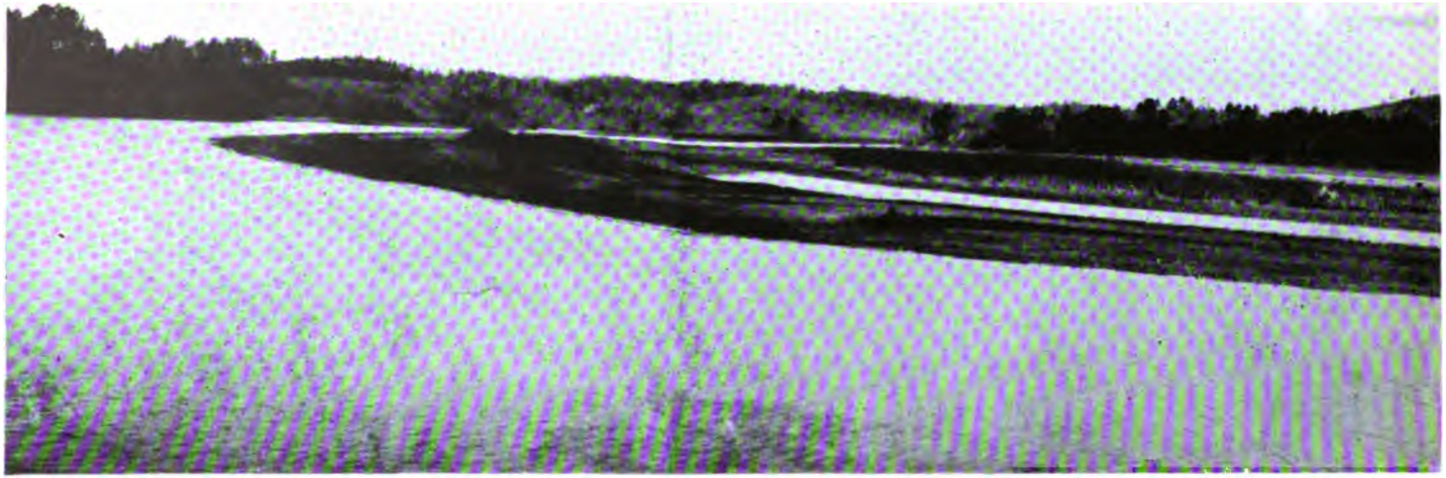

PHOTO BY S. W. M'CALLIE, STATE GEOLOGIST OF GEORGIA

PONDAGE REDUCED THROUGH SILTAGE

Silt beds filling the upper end of Bull Sluice Reservoir, Chattahoochee River, Ga., and greatly reducing the pondage. These deposits have been built up by the most fertile soil washed from thousands of hillside farms

RELATIVE VALUE OF FOREST AND OTHER COVER IN REDUCING EROSION OF SOIL

It is sometimes claimed that any other ground cover or even masonry dams will adequately replace the forest as a protective agency. (Pl. 7). In the case of brush the protective efficiency may be as great as that of the forest; but brush provides no merchantable products such as woodland produces and is therefore uneconomical. In the case of grass, it is more than doubtful if its protective efficiency is as great as forest in the Rocky Mountains, south of Idaho, and in the southern Appalachian and southern Piedmont regions which are the regions where protection is most urgently needed. In these regions there are many types of soil and many sites—warm and dry southern slopes—on which a permanent sod can not be maintained. To be handled as a profitable investment on such sites, grass must be reset at frequent intervals. At such periods the naked soil is exposed for several months. In contrast, the continuity as well as the completeness of the protection afforded by woods, if fire is kept out, is of the highest value.

Another advantage of the forest is the greater permeability of the soil—the deep-root zone, 3 to 4 feet, penetrated by the many channels resulting from the decay of roots and rootlets as far down as the roots extend. The influence of the roots of trees is evident wherever a new road is cut through a forest; for along the sides of such new excavations during wet weather streams of water can be found trickling and even spouting from root holes as far down as 3 or 4 feet below the surface.

The statement has been made by Mead[13] that the forest cover exercises no influence on permeability. This may be largely true of sandy and glaciated soils, such as he had under observation in northern Wisconsin, and it probably holds true for such soils independent of location. One of the steadiest small streams in the Eastern States is Hitchcock Creek, Richmond County, N. C., a sand-hill stream with little vegetative cover on the stream basin but with a highly absorptive soil. A test which was conducted a few years ago by the author shows the comparative permeability and depth of the root zones of the forest and grassland, and yields results of most positive significance. Adjoining areas of forest, old grassland, and old farm land, with the same slope and aspect, were selected, and during the winter, when transpiration of moisture by the forest was largely eliminated as a factor, measurements were made of the moisture content of the surface soil and of the subsoil at 3 feet. The forest soil during the winter was invariably the most dry, showing the greater permeability. The subsoil of the grassland, deficient in root drainage, was usually wetter than the forest soil, also the surface soil of the grassland was often wetter. Both surface soil and subsoil of the naked land were always wetter than those of the near-by forest, except where the naked surface soil had been dried out by high wind. Newly cleared land, however, exhibited nearly the same conditions as that bearing forest trees.

Of all surface covers which can be employed in reducing soil erosion the forest is the most efficient and most permanent. The mat of leaves and humus forms an uninterrupted cover, and the deep roots render the subsoil very permeable to water.

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[13] See footnote 8.

COST AND VALUE OF REDUCTION IN EROSION THROUGH FOREST PLANTING

In the Southeast there are already many reservoirs which have in whole or in part lost their storage capacity through silting because the catchment basins were not so protected as to prevent erosion of the soil (pl. 8); but, as has been pointed out, excessive erosion of soil is not a normal condition, and the fact that certain reservoirs have been impaired by siltage in no way reflects upon the value of storage reservoirs well located, and for which, if they are efficiently protected, permanence can be assured.

In the regions of deleterious erosion it is desirable for the hydroelectric engineer who contemplates complete development of water resources—that is, the utilization of storm water by storage—to have the benefit of a protective cover for impounding basins. It is not a difficult matter to compute, on the one hand, the relative value to a community of farm land of comparatively low productivity and on the other hand, that of the same land in forest supporting a permanent forest industry and affording the assurance of permanent power for nonforest industries. This permanency of additional power, obtained through storage of water, may in itself far more than offset the loss of the use of the land for agriculture. Water-power resources are essential to the continued future development of a region.

There are undoubtedly cases where it would be desirable to go to the expense of protecting the surface of land by forest planting in order to obtain a reduction in erosion. In considering a policy of planting to protect the surface, those lands should be selected first which are eroding at the most rapid rate and which are so situated, that the detritus from their surface is deposited most directly in the reservoir.

In case lands can be acquired below certain prices, these prices varying in proportion to the earning capacity of the lands, it will be possible to plant them to forest with the expectation that the growth of timber will pay or more than pay the carrying charges and interest on the investment in planting. The lands which are most urgently in need of planting are largely either idle farm lands or farm lands which are being cultivated and consequently are comparatively high priced. Frequently the combined cost of land and of planting is so high that the returns in timber probably would not be equal to the current rate of interest. In case it is found that the land can not be acquired at a price which will justify the purchase for growing timber alone, it may be possible to meet the increased costs by investing an amount which represents the capitalized value of the enchanced or lengthened utility of the reservoir.

AN EXAMPLE

A reservoir has an initial utility value for storage of $2,000,000 or 32,000,000 kilowatt hours a year, the cost of storage being well within the limits of profits on the investment. It is determined that the turbidity of the impounded stream and the rate of deposit of silt in the reservoir are such that three-fourths of the storage capacity, or 24,000,000 kilowatt hours of potential power a year, will be lost within 40 years. To what expense, if any, would the owner of the water rights be justified in going so that at the end of 40 years the reservoir would have three-fourths of the storage capacity or 24,000,000 kilowatt hours of power a year? (Fig. 1.)

In case erosion should continue unchecked, at the end of 40 years there would remain only 25 per cent of the initial utility value or 8,000,000 kilowatt hours a year. The utility value is irrespective of whether amortization of the investment has been effected in whole or in part. The question then is: What sum could be expended by the owners of the reservoir, assuming that the purchasing power of the dollar remains unchanged, to give assurance of a utility value of $1,500,000 at the end of 40 years? This would be three-fourths of the original utility value, whereas, if erosion continued unchecked, there would remain a utility value of only $500,000. (Fig. 2.)

For the sake of greater simplicity and clarity it is assumed: That it would be possible to plant in one year all denuded lands the erosion from which is most serious, such planting taking place possibly during the construction of the reservoir so as to obtain immediately the continued full benefits of its lengthened utility; (2) that the rate of sedimentation in the reservoir proceeds at a constant rate until, except for the channel of the stream, it is completely silted up; and (3) that the utility value is abruptly decreased by one-fortieth at the end of each year. Actually, however, such a rate of silting is not constant. Sedimentation takes place at a diminishing rate as the reservoir fills in, as the area of slack water diminishes, and as the general current of the water through the reservoir increases; and the rate of sedimentation is also subject to great variation due to the occurrence of high floods or to long periods of even flow, and on account of eddies and convective currents the deposit as a rule is irregularly distributed.

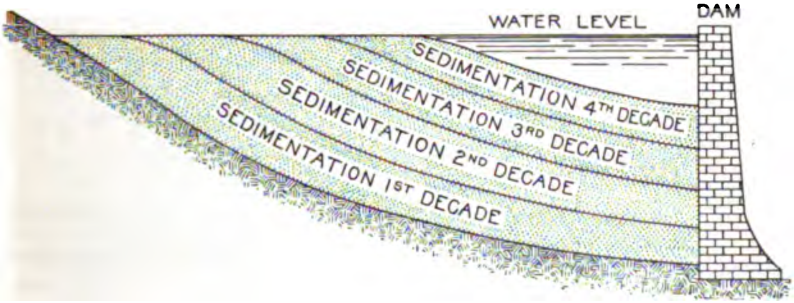


FIG. 1.—Decrease in storage capacity of a reservoir by decades, due to silting. schematic

As a result of planting, there is assurance of a utility value of $1,000,000 at the end of 40 years which otherwise would have been lost. Without planting, this value would have been gradually reduced year by year through the period of 40 years so that at the end of that time none of it would have remained. Consequently there would be a consecutive loss of storage capacity at the end of each year for 40 years. This loss would have an average annual value of $25,000 or 225,000 kilowatt-hours a year. Assume that by immediate action this loss is prevented. The storage capacity thus preserved would at the beginning of the year have a value equivalent to a sum which, placed at interest at the current rate, would amount to $25,000 at the end of the year. The present value of such storage capacity as would have been lost at the end of the fortieth year would be equivalent to that sum which, put at interest at the current rate, would then amount to $25,000. There would be corresponding values for the losses of the intervening years. The sum of these amounts would be the present value of the extended life of the reservoir which would result from planting. On this basis the present value of the storage capacity having a utility value of $1,000,000 at the end of 40 years would be $353,646. (Fig. 3.)

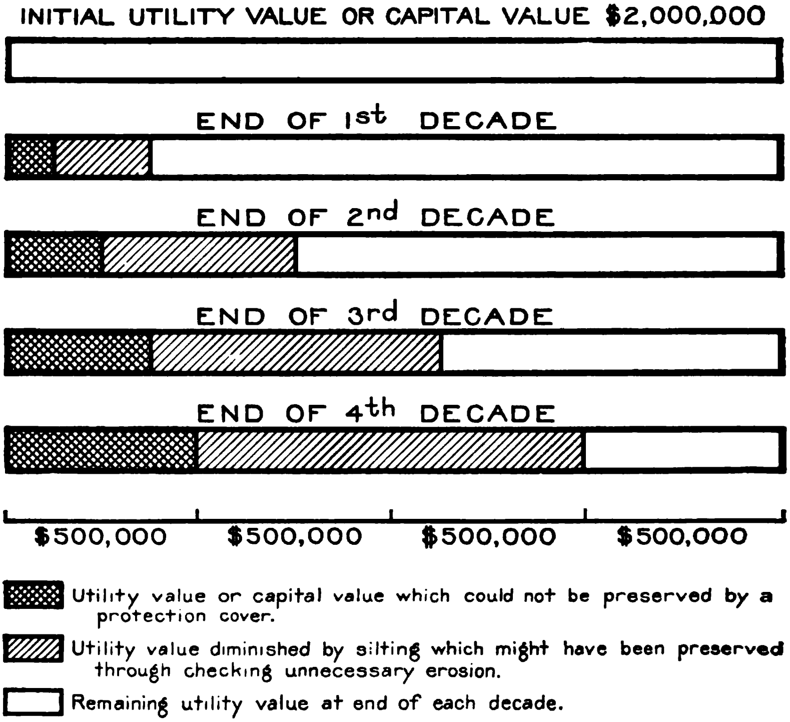


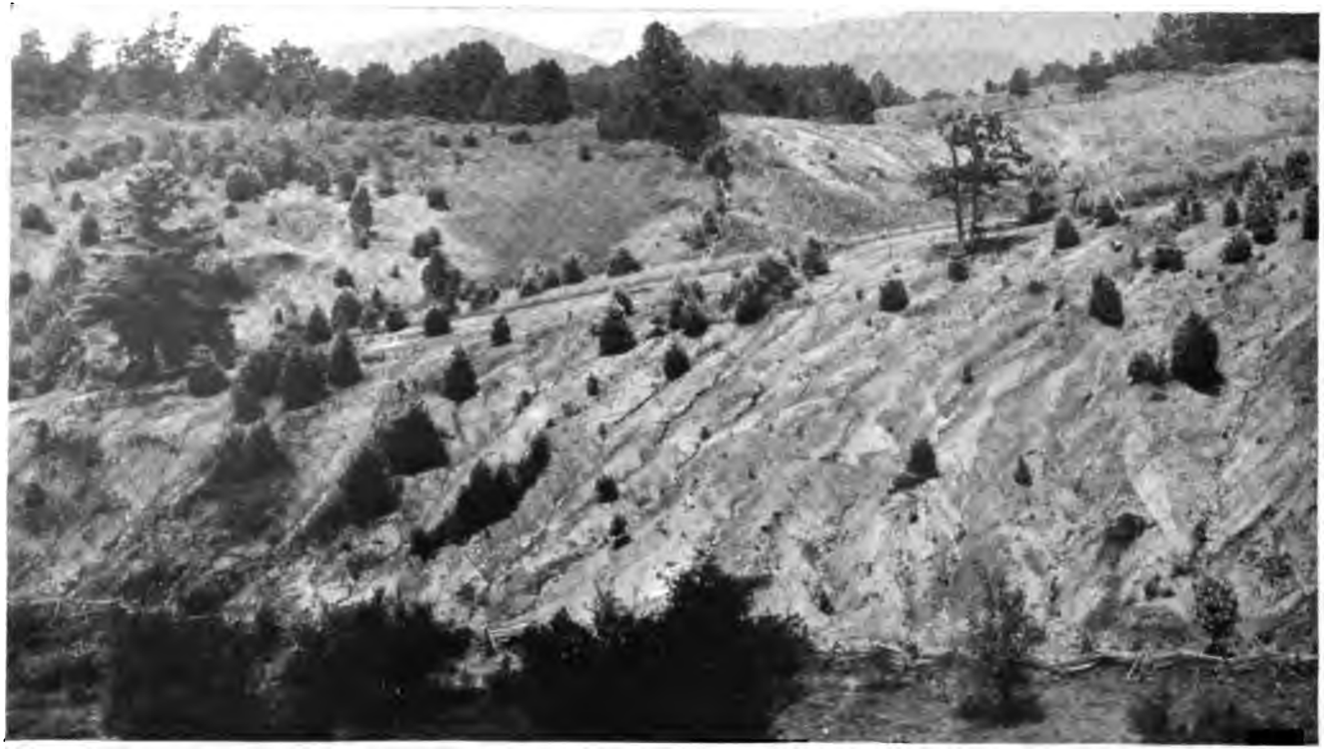
FIG. 2.—Decrease in utility value or capital value of a reservoir through silting

In this hypothetical case a location in the Piedmont region of the Southeastern States may be assumed and the short-leaf or rosemary pine of that region may be selected as a tree for planting. An examination of the basin shows that the denuded lands from which the larger portion of the turbidity is derived are, if planted in shortleaf or rosemary pine, of forest-producing quality No. 2. Without thinnings or other care than protection against fire and insects, a yield of 17,100 board feet, measured by the Scribner log rule, and 18¾ cords of merchantable wood, but of a size too small for saw

F185509

HOW TO MAKE THE RED HILLS PROFITABLE

Plantation of 10 acres of native pine 35 years old, Spalding County, Ga., cutting about 17,000 feet per acre. Red clay soil, hill country of southeastern Piedmont



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WHERE EROSION OF SOIL CAN BE PREVENTED

Badly gullied hillsides. Natural restocking beginning to take place. This should be supplemented by planting to establish a protective cover for the soil timber, can reasonably be expected at the end of 40 years from such a site. (Pl. 9.)

The present general value of the timber of this tree in stands 40 years old is about $3.50 a thousand board feet, log scale. During the past 40 years, timber of this kind has increased in value at the rate of about 5 per cent compounded annually, or from about 50 cents to $3.50 a thousand board feet (disregarding the shrinkage in the purchasing price of the dollar). In case timber of this kind, instead of continuing to increase in value at a rate of 5 per cent, should increase at a rate of 4 per cent during the next decade, and at a continually declining rate each subsequent decade to the end of the 40-year period, so that the average rate of increase for the entire period would be 2.6 per cent compounded annually, its value at the end of that time would be $9.51 per thousand board feet. (Fig. 4.) It is believed that the rate of increase will as a matter of fact greatly exceed this. Cordwood of a character suitable for paper-pulp stock will probably have a value of not less than $2 per cord at that time. There could thus reasonably be expected from planted stands a gross return of $200 per acre (the computation shows $200.12), of which approximately $163 would come from the sale of saw-timber stock and the remainder from the sale of cordwood. Such figures undoubtedly seem extremely high, but they are not out of proportion to the increase in the value of timber of the same class which has already taken place in Maryland, and are at a considerably lower rate than the increase in value which has taken place in the case of second-growth white pine in New England.[14] Taxes on such land can be assumed at 20 cents an acre a year, totaling, with interest at the current rate of 6.5 per cent a year, $36.66 at the end of the period of growth; while the cost of protection can be assumed at 3 cents an acre a year, likewise compounded at a rate of 6.5 per cent for 40 years, totaling $5.50 per acre. If these two items of expense, amounting to $42.16 are deducted from $200.12, the estimated total gross receipts from the sale of the timber, there is a balance of $157.96.

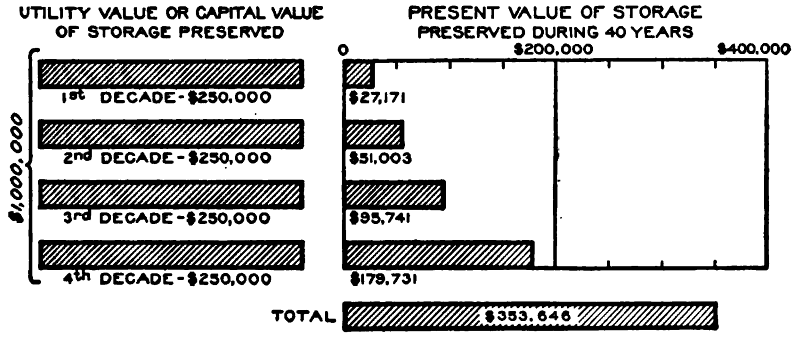

FIG. 3.—Present value, by decades, of $1,000,000 utility value preserved by reducing erosion

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[14] During the last 25 years second-growth white pine in middle New England has increased from $2.70 a thousand board feet in 1899 to $14 per thousand board feet in 1924, or at a rate of more than 6.5 per cent compounded a year.

An initial investment of $12.50, at a rate of interest of 6.5 per cent compounded annually, will amount to $157.96 at the end of 40 years. Consequently the owner of water rights would be justified in going to an outlay of this amount per acre for the purchase and planting of lands with the expectation that the sale of the products from this land would return the initial investment and would cover the interest on this outlay at a rate of 6.5 per cent per annum compounded.

There are areas of denuded lands on which restocking to trees could be expected, at least in part, from seed scattered by near-by old pines. There are other lands which would require planting, either because it would be necessary to check erosion at once or because there are no near-by seed trees. (Pl. 10.)

An average present figure for planting short-leaf pine in this section, including the growing of 2-year-old stock, would be about $8 per acre. Many and in fact most lands requiring planting for their protection have recently been in cultivation. On such lands it would be possible without difficulty, by means of a large bull-tongue plow or shovel plow with coulter attached, to lay off rows within which planting could be done. This would cheapen the cost of outsetting.

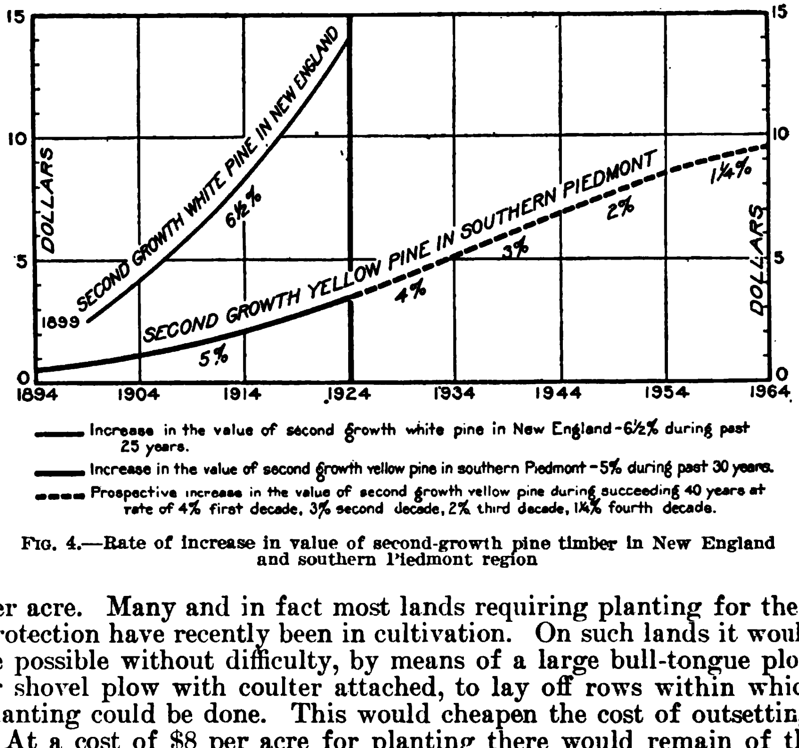

FIG. 4.—Rate of increase in value of second-growth pine timber in New England and southern Piedmont region

At a cost of $8 per acre for planting there would remain of the $12.50 only $4.50 an acre to be applied to the initial cost of the land. It would be necessary that the remaining expense of purchasing the land be charged as an element of cost in maintaining the utility value of the reservoir. The fund of $353,650, given above as representing the present value of the additional utility of the reservoir at the end of 40 years, can be drawn upon for the balance of the money necessary to complete the purchase of the land and to protect it from fire.

An examination of the basin of a stream might show that practically all of the erosion, including the heaviest portion of the solid burden which enters the reservoir, consisting of the large sand, the small sand, and the coarser silt, is derived from approximately 6,000 acres of steep land now being cultivated annually to tilled crops, and that there are in addition 4,000 acres of land the erosion from which is less serious, but on which erosion should be checked within a period of not more than five years.

It is ascertained that the 6,000 acres can be acquired at an average price of not more than $15 an acre and can be planted at a cost of not more than $8 an acre. These lands, being hilly, are of low productivity in farm crops but are of good productivity in timber. In addition to expending $12.50 an acre, which represents the value of the land when planted for timber production, it would be financially advantageous to expend a sum not exceeding the $353,650 mentioned above.

An examination of the 4,000 acres on which erosion is less active might show that natural seeding from near-by old trees could be expected to restock this land in forest growth within a period of five years, and that consequently it would be unnecessary to resort to the expense of planting, so that the purchase price of the land, allowing for natural restocking, would be within the investment value of the property in growing timber.

SETTLING BASINS

In addition to planting, it is possible and even desirable in some places to employ settling basins, within which much of the heaviest material at least may be left by natural elutriation. For this purpose, rough alluvial lands should be selected which have been injured by gullying during floods or upon which sand or gravel bars have been deposited. By means of low and inexpensive dams such lands can be flooded. The deposit from the slow-moving water will, in a few years—the period varying with the amount of sedimentation height of dam, and rapidity of current—reach the top of the dam, except in the stream channel. The dam will then have performed its function. Settling basins are therefore a temporary expedient. They may be employed with a view to preventing loss in storage capacity of the reservoir while a planting program is being worked out and executed. (Pl. 11.)

Lands built up by means of a settling basin may be made valuable for farming purposes by the removal of a portion of the dam at one point so as to permit the stream again to seek its normal or former channel bed. Soils so deposited are free from stone and gravel and enriched by the sedimentation from the slack water. Deposits of this kind frequently fringe the entire upper margins of large reservoirs. Such, for example, are the deposits in the reservoir at the Muscle Shoals[15] development, which in places would now be suitable for agricultural use if the water table were lowered only a few feet. Artificially formed alluvials of this kind after the removal of a portion of the dam are level and would generally be above the flood line of the stream. Furthermore, they would not be subject to excessive surface erosion so long as the greater portion of the retaining dam remained intact. Their level surface, great fertility, ease of cultivation, and immunity from flooding render such lands extremely valuable for farming purposes. As the stream cuts its new channel to the depth allowed by the removal of the dam, it might be desirable to plant to stream side shrubs, the bank thus being formed, in order to prevent corrasion and restrict meandering.

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[15] See footnote 5, reference to p. 111.

PLANTING A WOOD

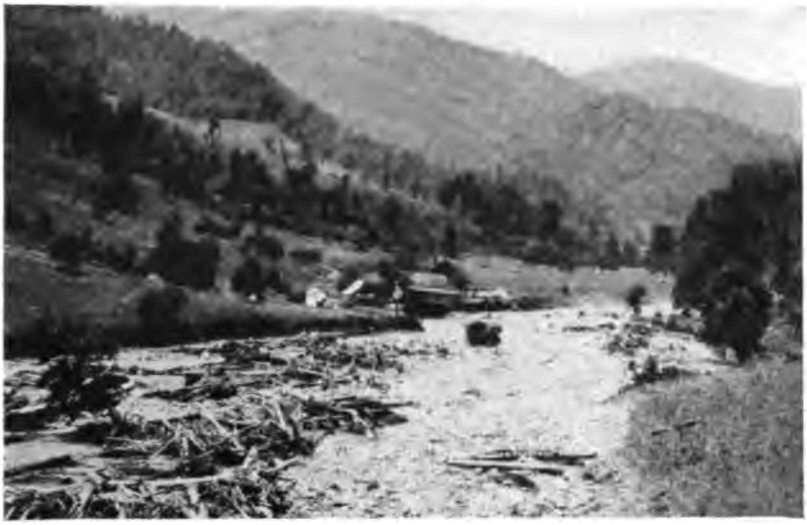
In considering plans for forest planting a decision should first be reached as to the most desirable species to employ. In making such a choice full weight should be given (1) to the health and vigor of different species, (2) to the cost of propagating stock for planting, (3) to the ease of planting, and (4) to the initial rate of growth of the kind of tree from the point of view of obtaining a suitable soil cover within the shortest period. Such consideration should have as much weight as the value of the timber that would be produced by the stand within the period of growth.

Native trees as a rule should be selected. A careful study of the site should be made to ascertain which of the native species is most suitable for the site, and the quality or productive capacity of the site for the species in question should be ascertained. For their value in growing timber, soils are classified on the basis of the number of cubic feet of solid wood of a specified kind of tree that can be produced within a given period. If other than a native species is selected, it is more difficult to decide upon these points.

The following native species are particularly to be recommended for planting for protective purposes in the sections for which designated, but they by no means include all of the desirable native species. High altitudes and particularly unfavorable sites, including very dry or stony, shady, or wet sites, demand special species.

In the Northeast, in the upper Mississippi Valley, and in the southern parts of the Lake States, the white pine is the most desirable conifer for general conditions on sites to which adapted, and when not subject to destructive diseases and pests. Norway pine is suitable for sandy or poorer sites. If a hardwood species is to be considered, red oak is unexcelled either by itself or in mixture with white pine, although the white pine as a rule will outgrow the red oak. In the Appalachians white pine is the desirable conifer for medium and higher altitudes particularly on the drier sites; and yellow poplar and red oak are the most desirable broad-leaved species. In the southern Piedmont regions and the lower Mississippi Valley and in the Ozarks shortleaf or rosemary pine on the uplands with southern red oak on similar sites and yellow poplar on moist (not wet) sites are the best suited species. In the northern Rocky Mountain region and on the northwest coast western white pine and Douglas fir can be expected to give the best results under average conditions. In the Southwest on medium sites the western yellow pine is the desirable tree, but the species, preferably a local one, should suit the site and altitude.

PLATE XI



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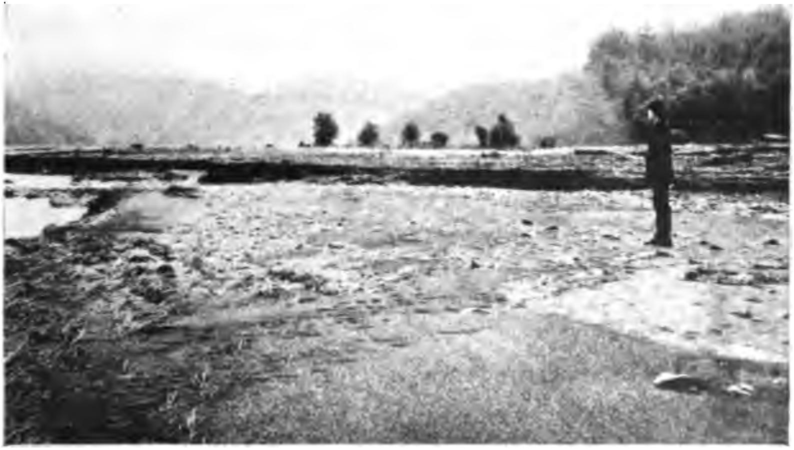

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SITES FOR SETTLING BASINS

Alluvial lands, headwaters of Catawba River, N. C., injured or destroyed by floods in 1916. They represent ideal sites for the location of settling basins to collect large quantities of sediment which otherwise would reduce the pondage of reservoirs on this river. In time level alluvials very valuable for farming would be built upon the sites of the settling basins

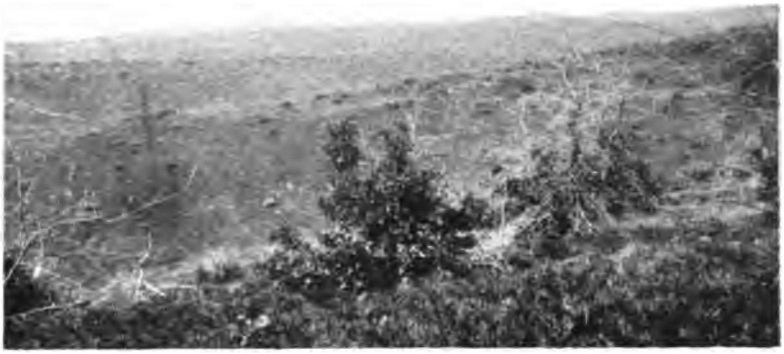

FIG. 1.—Bayfield County, Wis. Hills of coarse sand and gravel stretch to the horizon. Once heavily forested, now denuded and periodically fire swept. On account of the porosity of these soils there is comparatively little erosion. The sandy soils supplemented by lake storage result in low flood stages in the streams and high summer run-off. Typical of the Great Lakes region

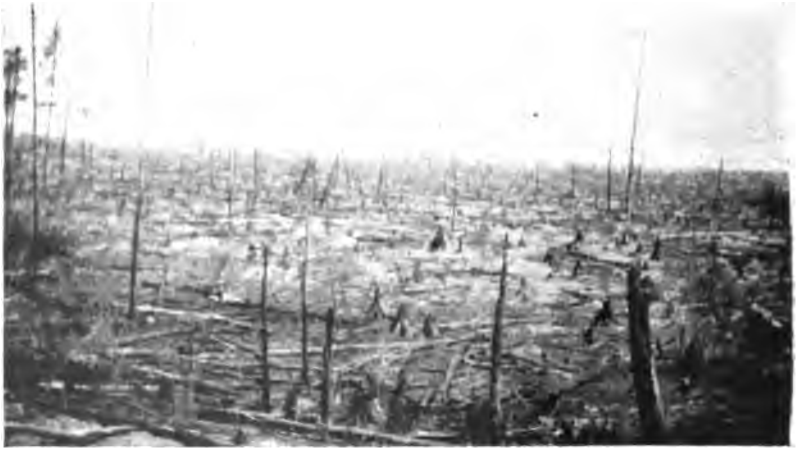

FIG. 2.—Undulating forest land with sandy soil, recently lumbered and just burned over, Marquette County, Mich. Unless protected against fire this land will soon be similar to that in Figure 1. There is, however, even when the surface is broken, little erosion on such sites, because of the porosity of the soils

FOREST INFLUENCES LOW

REGIMEN AND TURBIDITY OF THE MAIN STREAM SYSTEMS IN THE UNITED STATES

The important factors which determine (1) the volume and (2) the character of the flow of streams of the United States are:

Source of water supply; amount, character, and distribution of precipitation.
Lake storage.
Underground storage.
Character of surface of the basin.
Character of soil and subsoil and especially its susceptibility to erosion.

The streams of the United States may be separated into eight groups, on the basis of regimen, turbidity, and the influence of forest protection on their watersheds:

Rivers of the Northeastern States and the Great Lakes region.
Rivers of the Middle Atlantic coast region.
Rivers of the southern Appalachians.
Rivers of the eastern slope of the Rocky Mountains.
Streams rising in the plateau region of central Texas.
Colorado River and interior basin.
Sacramento and San Joaquin Rivers.
Columbia River.

RIVER SYSTEM OF THE NORTHEASTERN STATES AND THE GREAT LAKES REGION

The northeastern and Great Lakes regions embrace the rivers in the New England States, the Hudson River, the rivers in the region of the Great Lakes, and the headwaters of the Mississippi. The basins of the streams of the northeastern region are well forested as a rule or their surfaces are well covered. The natural permeability of the soil depends largely upon texture and structure, and the absorptive and water-holding capacities are increased by a good humus content. Many of the soils of this general region are of such character as to accumulate and maintain a liberal quantity of organic matter. The freezing of the soil during a considerable period of the year not only protects it from erosion but also retards the oxidation of its humus. The humidity is relatively high and the evaporation low. An extensive system of lakes acting as natural reservoirs, at the heads of many of the large rivers, is instrumental in furnishing an equable stream flow from a moderate but evenly distributed precipitation of 30 to 40 inches, which in winter occurs largely as snowfall, and which passes off as spring freshets after warm rains. Dams at lake outlets increase storage. Natural storage is also favored by the deep glacial drift and the spongy moss and deep humus. Except on very sandy soils, sod naturally sets in ditches, on stream banks, and in waste places, and forms nearly as perfect a protection against erosion as the forest cover. Erosion is slight and the silt burden of the streams is insignificant.

The Kennebec River may be taken as a type of the streams of the northeastern group. The tidal estuary which forms its mouth is free from silt bars, and this indicates the small quantity of solid material which it bears. In the discussion of Portland Harbor by the Chief of Engineers,[16] the statement is made that "There are no silt-bearing streams emptying into Portland Harbor, and the improved depths obtained * * * will be practically permanent." Although many of the New England streams carry silt, the burden is small when compared with that of southern and southwestern streams.

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[16] MACKENZIE, A. IMPROVEMENT OF RIVERS AND HARBORS IN MAINE AND NEW HAMPSHIRE. [U. S.] War Dept. Ann. Rpt. 5: 33. 1906. (Rpt. Chief Engin., U. S. Army.)

The high spring freshets resulting from the melting of the accumulated winter snows are followed by well-maintained midsummer flow. The relation between the minimum flow and the maximum flow is less than 1 to 100. The Connecticut River is the least steady of the streams of this group in its flow, because a large portion of its basin is located on the steep slopes of the White Mountains and other mountains of northern New England, and because of the comparatively small lake surface.

The Hudson River is similar in general characteristics to the New England streams; but its chief tributary, the Mohawk, drains a thoroughly cleared agricultural valley, and during freshets bears a moderate silt burden. That portion of the river above Troy which comes from the Adirondacks nearly duplicates in general character the streams of Maine. The silt burden of the Hudson, which has increased with the extension of the cleared area, amounts to 240,000 tons a year, a larger quantity than is borne by the rivers of New England, with their better-forested watersheds and better-granulated soils, but smaller than that carried by the large rivers of the southern Appalachians.

The streams of the Great Lakes region, which include the headwaters of the Mississippi River, with the St. Croix, Wisconsin, Chippewa, and most other rivers of Wisconsin, Minnesota, and northern Michigan, are similar to those of New England in lake feeding, but the soils are more sandy; there is less surface relief and while the forest condition of their basins is poorer, the extent of forest influences on their flow is less. (Pl. 12, figs. 1 and 2.)

Erosion, on the whole, is so slight in this region that the Mississippi River above Minneapolis, with a basin of 19,585 square miles, has a yearly silt discharge of only 117,000 tons, compared with nearly 11,000,000 tons from the Tennessee River with less than twice the drainage area of this portion of the Mississippi; that is, the solid burden at the Tennessee River is about fifty times that of this portion of the Mississippi River.

The soils of the basins of the streams in the Lake States region are prevailingly loose and possess a high storage capacity. However, they are locally deficient in cohesion, and where this is the case the banks of even small streams corrade during the spring freshets. This produces sand bars, especially in some of the streams of Michigan, such as the Grand, Au Sable, Kalamazoo, and Muskegon Rivers. There is evidence that erosion of soil from the upland denuded of forest has contributed to these deposits, since, and especially in the southern portions of these States, there are areas of clays and loams which are subject to erosion whenever the surface gradient is suitable, although the general setting of grass, the long winters, and the moderate summer rainfall contribute to reducing it to a minimum.

Extensive areas in the Lake States are of only marginal value for farming, but have been cleared for that purpose. After a futile attempt at cultivation, the greater portion of these farms have been abandoned. Few of these abandoned lands restock to trees, although coarse grasses, chiefly broom grasses (Andropogon) usually soon clothe them. The area of such abandoned farm lands in the Lake States is estimated to be not less than 5,000,000 acres. In addition, there are estimated to be more than 31,500,000 acres of burned or cut over and subsequently burned or devastated forest land in this region, largely destitute of tree growth but often with fair ground cover of grasses and small shrubs. Even in the most rugged regions there is a minimum of erosion on these sites because of the sandy or gravelly soils. Except locally, as in the protection of stream banks or when the soils are clayey, forest cover exercises a low protective function in most portions of the Lake States region.

In the New England States, however, the demarcation between absolute forest lands and those lands most suitable for farming is usually sharply drawn. For this reason further encroachment upon the forest lands for farms will not be extensive; and, if the forest conditions are not destroyed by injudicious lumbering, the present conditions of stream flow can probably be maintained.

RIVERS OF THE MIDDLE ATLANTIC COAST REGION

The most important streams of the Middle Atlantic coast group are the Potomac, the Delaware, the Susquehanna, the Rappahannock, and the James Rivers. There should be included with this system the Allegheny and Monongahela and certain other head streams of the Ohio which lie within this general region and exhibit similar characteristics of flow.

These streams rise in the Allegheny Mountains, where for the most part their headwaters drain narrow agricultural valleys inclosed by forested but thin-soiled though permeable shale and sandstone ridges. The lower portions of their basins are largely cleared and have rather heavy soils and frequently poor humus conditions, both in the forests and in the agricultural lands. The forest humus, derived chiefly from oak, chestnut, and pine, is naturally scant, except at high altitudes, and has been further reduced over large areas. Burning resulting in insolation of the soil and the compacting effects of heavy rains have resulted in light erosion.

Stream flow is maintained by a rainfall of from 40 to 50 inches, a feature of which is a heavy, irregular midsummer precipitation, compared with 30 or 40 inches of precipitation on the basins farther north. The considerable winter snowfall is usually removed by warm spring rains, causing floods, which corrade the banks of streams and also erode the agricultural lands. (Pl. 13.) In addition there are frequent summer and fall floods, all accompanied by a large silt burden in the streams. The floods damage canals and riparian property, and the silt is deposited in the estuary channels, where constant dredging is required to maintain depth.

The silt which is annually discharged by the Susquehanna River at Danville, above which point the basin of the river has an area of 9,530 square miles, amounts to 240,150 tons. On the James River it has been estimated[17] that, in a flood with a 10-foot crest, from 275,000 to 300,000 cubic yards of solid matter are moved during

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[17] HAINS, P. C. IMPROVEMENT OF THE JAMES RIVER, VIRGINIA. [U. S.] Sec. War Ann. Rpt. 2 (pt. 2, app. J): 947. 1885. (Rpt. Chief Engin., U. S. Army.)

24 hours. The discharge of sediment by the Susquehanna had become so excessive by 1871 that it was found necessary that year to abandon the Brewerton Channel to Baltimore in Chesapeake Bay, since this channel was continually obstructed by the sediment deposited in the eddy made by the currents of the Patapsco and the Susquehanna Rivers. The average turbidity of the Susquehanna is 21 parts per million, and that of the Potomac and James Rivers is higher.

A most notable power development on the Susquehanna River is the projected plant at Conowingo, where it is estimated the initial generation will render available 300,000 horsepower, and possible additions will produce 500,000 horsepower, thus placing this river in the class with the Tennessee as one of the great power streams of the Eastern States.

These streams lack the natural reservoir system of lakes which characterize the streams of New England and many of the streams of Wisconsin, Michigan, and Minnesota. They also lack the sandy or glacial soils of the northern river basins, which possess ample water-storage capacity. Moreover, the thinner humus of the oak and chestnut forests of the Middle Atlantic coast region offers only a meager water storage compared with that of the thick spruce duff and the moss of the more northern streams.

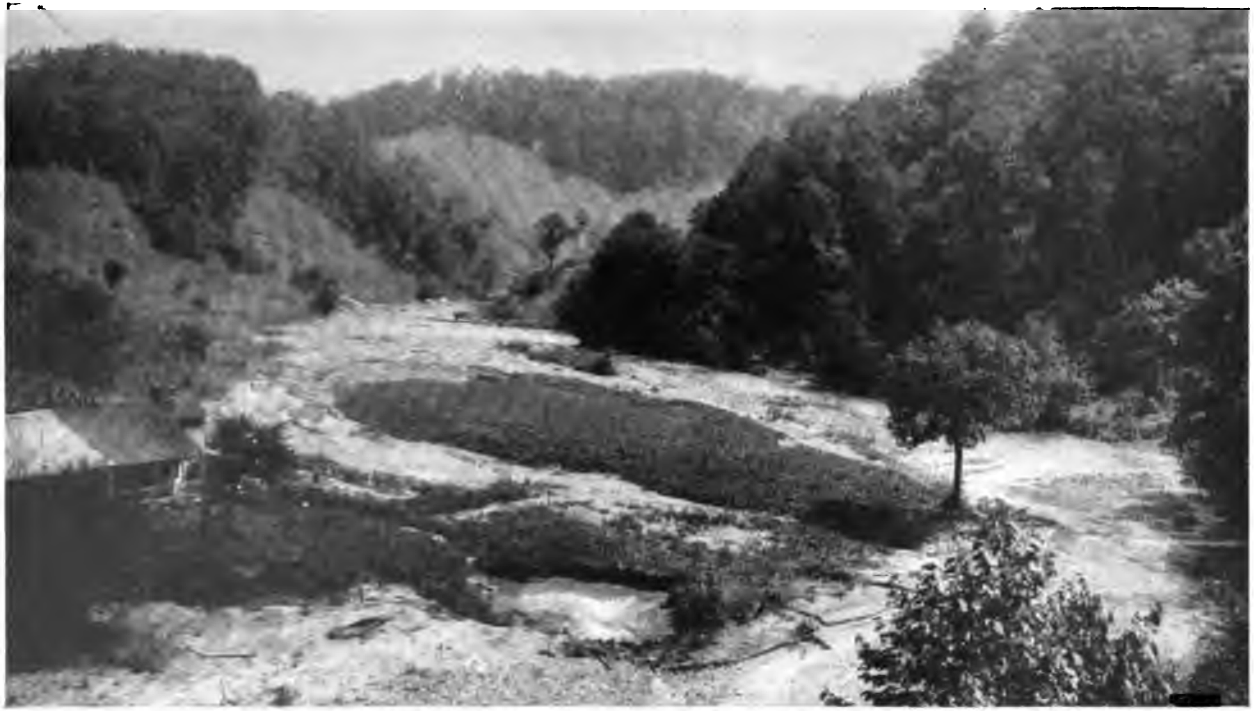
These conditions of soil and climate, which are so unfavorable for equable stream flow, attain their maximum on the lower reaches of the most southern streams, the Potomac and James. Here the rainfall is heaviest and most irregular, the protective humus is thinnest, and the heavy clay soils of the Piedmont Plateau, naturally deficient in granulation and absorptive capacity, replace the more permeable though shallow sands and loams of the upper portions of their basins, where the conditions are more nearly like those determining the clearness of New England streams.

RIVER SYSTEM OF THE SOUTHERN APPALACHIANS

The southern Appalachian group includes a very large number of rivers the flow of which is characterized by high floods at irregular intervals, usually highest in the spring, followed by long intervening periods of low water.

This river system embraces the greatest number of navigable rivers in the United States and has the greatest mileage of navigable waters, although at the present the rivers are very little used in comparison with the actual possibilities. The total power resources, minimum flow, are placed by the Geological Survey at 3,340,000 horsepower.

On the southern Atlantic drainage the Roanoke, the Neuse, the Cape Fear, the Peedee, the Santee, the Savannah, and the Altamaha Rivers are all important streams. With these can be included the White River and other streams of the Ozark region. On the Gulf drainage the Apalachicola, the Black Warrior, and the Mobile River systems embrace many hundred miles of navigable waters and traverse the coal fields of Alabama. The Tennessee, the Cumberland, and the Kentucky River basins cover the entire State of Tennessee and portions of other States. (Pl. 14, figs. 1 and 2.) The rivers have their sources in the southern Appalachian Mountains or in the adjacent plateau regions. In the lower portion of the Mississippi



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CORRASION OF BANKS AND MEANDERING STREAMS

This frequently follows land greed, and results from cutting of all trees and shrubs along the streams' banks and cultivation to the very water's edge. The consequence in this case and in many others is that all alluvial land is destroyed

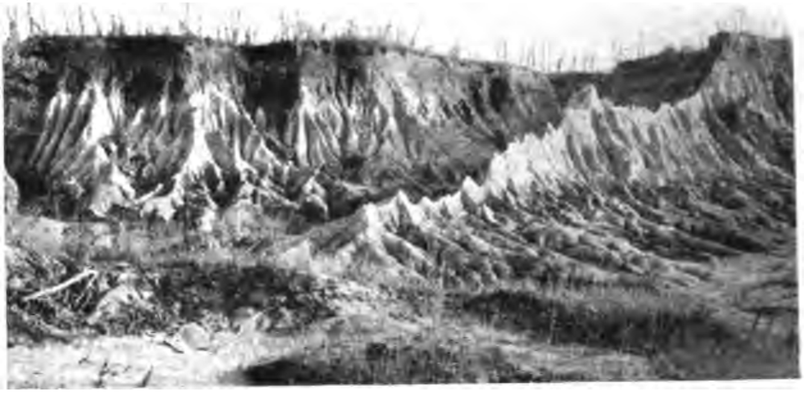

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FIG. 1.—Once a part of a farm. Corn can be seen on the land still in cultivation. Fayette County, Tenn.

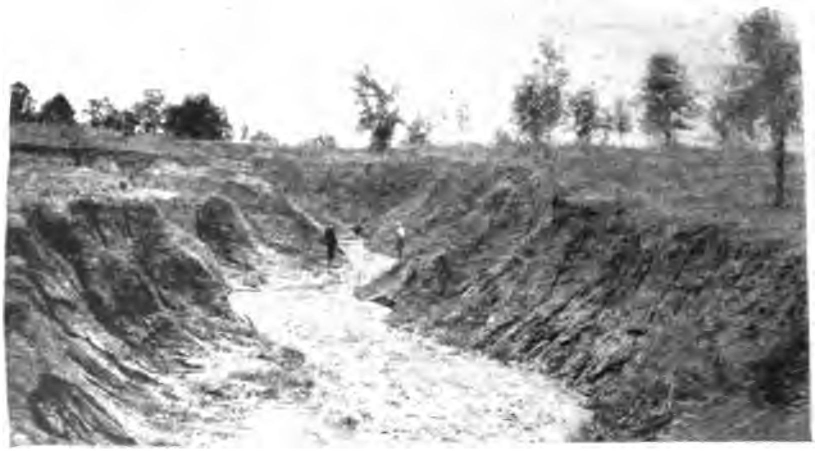

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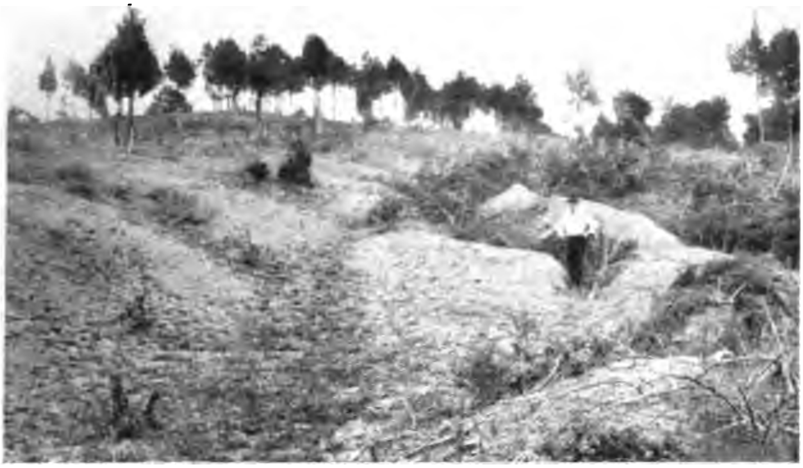
FIG. 2.—A strip from this field has had free transportation down the Tennessee River. Carroll County, Tenn.

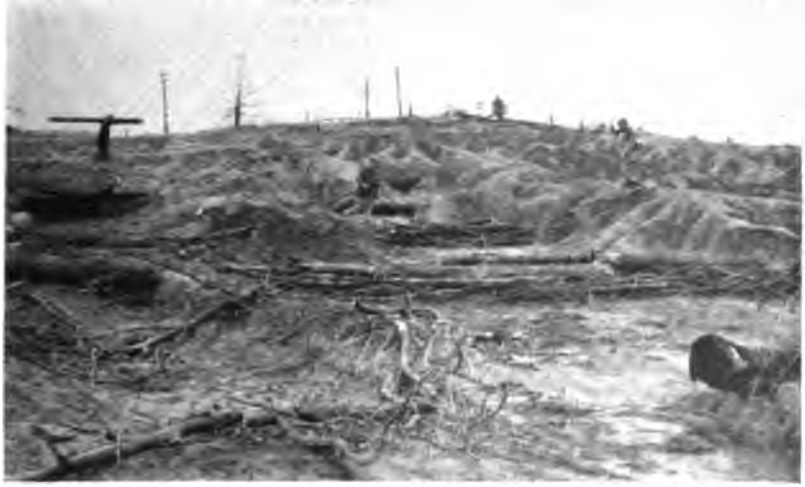
EROSION OF FARM LAND

The yearly burden of the Tennessee River is 11,000,000 tons of soil, in large part from lands such as these. The Army engineers' report on the Tennessee River notes the extensive deposits of silt in the reservoir at Muscle Shoals already materially reducing its pondage



OPPORTUNITY FOR PLANTING TREES

FIG. 1.—Employing brush in gullies to hold earth washed from slopes above the gullies. Planting trees is permanently more effective



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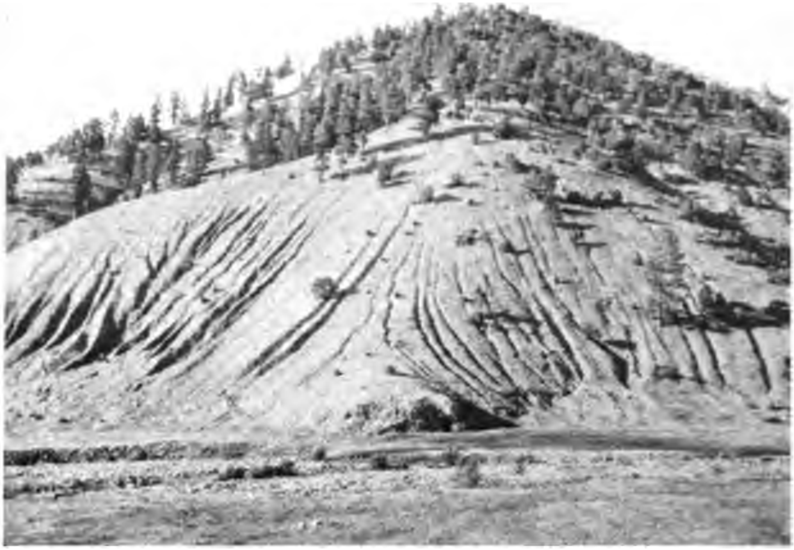
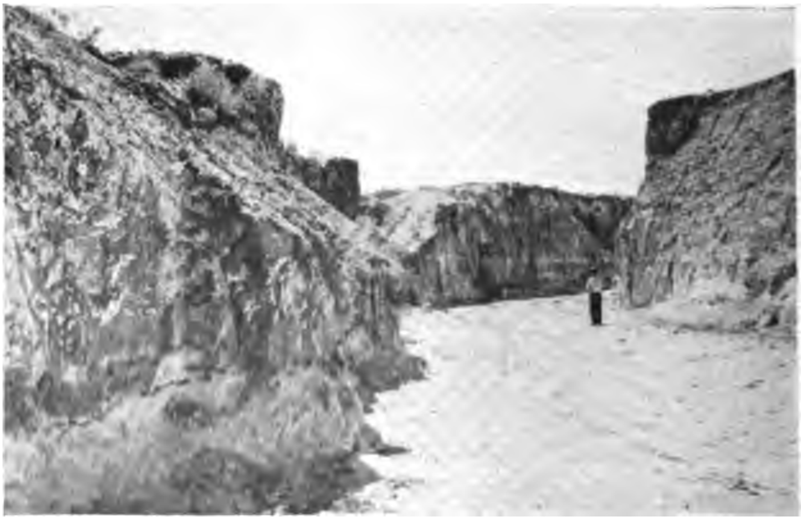
THE WRONG USE OF TREES

FIG. 2.—Brush dams are an expedient for checking the deepening of gullies. If rough hillside lands were kept in wood, gullies would not form; the land would not be destroyed. Such raw spots should be planted to trees



PECOS RIVER. (TRIBUTARY OF RIO GRANDE)

FIG. 1.—Erosion following removal of timber cover and as a result of excessive grazing. Santa Fe Creek, N. Mex. Typical of the headwater region of the Rio Grande and the southern tributaries of the Colorado River



ARKANSAS RIVER

FIG. 2.—Erosion in dry gulch tributary to Fountain Creek, near Pueblo, Colo. Erosion of this kind is not an infrequent sequence of heavy rains in this region of unconsolidated soils which lack the protective cover of vegetation. Many similar arroyos can be found on the Pecos River, Rio Grande, and tributaries of the Colorado River in New Mexico

Valley there are a few streams subject to nearly the same influences, such as the Pearl River of Mississippi, which may appropriately be included.

Fifty-seven of the Appalachian streams have 9,241.5 miles of navigable water. Most of them are navigable many miles above the tidal limit. The power which can be developed from these rivers is in many instances as important as their use for navigation, especially in those regions which are remote from coal mines.

The most typical streams rise at high elevations, 3,000 to 5,000 feet, in the Appalachian Mountains where they are fed by many swift tributaries. Leaving the mountains, they flow less rapidly through the hill country of the Piedmont Plateau or the rolling farm region of the Mississippi Valley. There is an entire absence of lakes and natural reservoirs. The forest at present covers about one-third of the area of the different watersheds.

Except in the most rugged mountains, the soil mantle over the greater portion of this region is prevailing deep—in many sections from 20 to 50 feet. The soils may be separated into three classes: (1) Loams and sands which are fairly permeable and have high storage capacity; (2) silts which are less permeable and have a lower storage capacity, and which, on account of their friability, are subject when exposed to most destructive erosion (pl. 14, fig. 1); (3) compact clays deficient in granulation which have an extremely low absorptive power and a low storage capacity and which erode badly but seldomly destructively.

The lighter soils are the most extensive in mountains and are the sources of the steadiest perennial springs. The heavy clays are extensively distributed and cover thousands of square miles on the Piedmont Plateau.

The unfavorable effect of the prevailing close-textured soils upon stream flow is further increased by the conditions governing precipitation. The snowfall is light, except in the high mountains, and the annual precipitation of 45 to 60 and even 80 inches in some localities frequently falls in concentrated showers. At several places as much as 9 inches is recorded as falling in 24 hours and at one place 22 inches within two days. Such torrential rains are destructive to steep slopes which are not protected either by a well-matted sod or by forest.

Below the mountains the humus, both in forest and in farming soil, is generally deficient, the deficiency being greatest farthest south. This lack of humus is partly due to the climate and soil, which favor the rapid oxidation of humus and partly to fires and grazing, which cause its depletion in the forest. The climate is mild, the winters are short and frequently open, and the ground is not covered by snow. The summers are long, the humidity is often high, and the rainfall is irregular and concentrated. These conditions retard the formation of humus and favor its rapid destruction.

The proportion of cleared land on the watersheds is apparently not excessive, but the condition and situation of much of it tend to jeopard not only the value of the rivers but the permanency of the soil as well. Unfavorable soil conditions have become far more general since 1880. The cultivation of extensive areas of hill country below the mountains, especially of the red clays in the extreme

South, ceased between 1880 and 1900. The rural population moved to the factory towns; the negro labor migrated to cities. Many counties in the southern Piedmont region showed a decrease in rural population during these decades, and in many there was a decrease in the total population. The surface of the farm land abandoned in this manner was quickly hardened and lost its porousness. Only a small amount of the heavy rains is absorbed by it, and much water that should be absorbed runs off, augmenting the floods; while the springs formerly fed from the water stored in the soil have failed. The land itself has eroded in deep gullies. (Pl. 15, figs, 1 and 2.) More recently, in the decade 1910 to 1920, there has been a general decline in rural population throughout the entire United States. During this decade 38 per cent of all the counties in 16 Southern States, all of them agricultural counties, lost population. In North Carolina, this loss in rural population was accompanied by a decrease of 1,500,000 acres in the area of cultivated land. But the loss in agricultural population and the accompanying shrinkage in the area of land in cultivation is by no means confined to the Southern States. It is a serious problem in every section. Much of the land, thus abandoned has been subject to destructive erosion of soil.

The irregularity and concentration of the precipitation, associated with other unfavorable conditions, frequently produce high floods, particularly on such streams as the Cape Fear and the Neuse Rivers which have narrow channels, not only in winter and early spring, when warm rains release the stored waters of snow and ice, but during the summer and occasionally in the fall as well. In these violent floods the rise of water at the fall line of the rivers frequently amounts to from 30 to 60 feet, the narrow channel having, however, an important influence upon the height of flood crest. On the other hand, during periods of drought, which occasionally extend to 60 and 90 days, that of the summer of 1925 being of more than usual severity, and the deficiency in ground water having been carried forward into 1926, the stream flow decreases until the water in the channels is very shallow. Rises of 60 or more feet above low water are known to take place in the Cape Fear, the Alabama, the Cumberland, and the Ohio, as well as in other streams.

RIVERS OF THE EASTERN SLOPE OF THE ROCKY MOUNTAINS

Rivers of the group draining the eastern slope of the Rockies embrace many streams of great length flowing east and south through the Plains. The most important are the Missouri, the Yellowstone, the Canadian, the Platte, and the Arkansas Rivers and the Rio Grande.

These streams have an erratic flow. There is a period of high water in the late spring or early summer resulting from the melting of the accumulated snows of winter, folowed by a long period of extremely low water, with very high floods at irregular intervals. Many of them, however, are extremely valuable as sources of power and for irrigation, since it is probable that a large portion of the region in which dry farming has failed may eventually be made highly productive through irrigation. After the early summer floods the autumn stages of these rivers are usually low, while the high winds and temperatures of the Plains result in high evaporation, which reduces still further the run-off of the Plains. The rainfall on the Plains, 10 to 30 inches, consists chiefly of summer precipitation, which augments the flow from the mountain sources for a short time, but in autumn becomes insignificant. Most of their upper basins are naked or sparsely timbered with open stands devoid of humus, except at the headwaters where the forested areas are small compared with the extensive unforested areas below. (Pl. 16, figs. 1 and 2.) The mountain streams which feed these rivers are of low turbidity, being fed by springs and the melting of snow on the north slopes and the higher peaks. The snow waters are reinforced by the midsummer rains of the Plains which are heaviest in June.

It is from the treeless Plains that these streams obtain the greatest portion of the silt burden. The silt burden is so excessive that many of the rivers have meandering channels from the deposit of sediment which may be in transit for only relatively short distances before being deposited. In addition to the violent fluctuations between the maximum flow and minimum dry-season flow, the constant washing of banks and formation of silt bars in the shifting channels are serious problems. The material of these silt bars is largely deposited during the spring freshets, being carried in part from the banks of the smaller tributaries of the Plains and from the unconsolidated sands and silts which constitute the prevailing soils of the Plains; to a less extent it is material brought down in flood by the mountain streams.

The silt burden in these streams is among the highest in the United States. The Missouri above Ruegg, St. Louis County, Mo., with a drainage area of 528,700 square miles, has a yearly silt burden of more than 176,000,000 tons. The Arkansas above Little Rock, with a basin of 148,000 square miles, discharges more than 40,000,000 tons of earth. The maintenance of forest cover on the mountain slopes at the headwaters of these streams is essential. It is the mountain springs which largely maintain the late autumn run-off after the melting of the snows.

STREAMS OF THE GREAT PLAINS

The streams of the Plains include the Washita, the Cimarron, the Red, the Smoky Hill, the Republican, and the Kansas Rivers. So erratic is the flow, that the Smoky Hill River, one of the chief tributaries of the Kansas, with a drainage area of 8,000 square miles, has a minimum discharge during the low-flow season of only 10 cubic feet per second. A comparison of this with a typical eastern stream—the Potomac River at Point of Rocks, Md., where the basin has a drainage area of 9,000 square miles—shows that the minimum flow of the Potomac, which for a 12-year period is recorded as 990 cubic feet per second, is ninety-nine times as great as that of the headwaters of the Smoky Hill River. The headwaters of the Arkansas, which rise in the mountains of Colorado, show a much more steady flow than those of the Kansas. At Canon City, Colo., the Arkansas drains a basis of 3,000 square miles and has a minimum flow of 108 cubic feet per second, or a flow thirty times as great as that of the Kansas River.

STREAMS OF THE PLATEAU OF CENTRAL TEXAS

A number of rivers of Texas have their headwaters in the deeply fissured limestones of the Edwards Plateau region of the central part of the State. These streams are normally clear. They carry, however, during periods of flood, an enormous quantity of silt eroded from the gorges and channels of the small streams which indent and canyon through the plateau region. None of these streams heading on the Edwards Plateau are fed by melting snows. They are subject to wide fluctuations between minimum and maximum flow. The floods at San Antonio and at Cameron, Tex., on September 9 and 10, 1921, are extreme examples of the maximum flow of streams of this character. At Cameron the Little River increased from a normal low flow of 177 second-feet to a maximum discharge of 647,000 second-feet. The Colorado River, on which was erected the ill-fated dam at Austin, is another. At the time this dam broke, after 10 years of service, it was found that its storage capacity had been reduced 56 per cent during the decade as a result of siltings. T. U. Taylor reports that the new reservoir, constructed in 1913, had lost 84 per cent of its capacity through silting by 1922. (Pl. 17.) The silt burden of the Colorado River (of Texas) is roughly estimated at 1 per cent of its volume or an average of 18,000 acre-feet a year. The Weather Bureau records show a rainfall of 0.9 of an inch within five minutes at Taylor and 4.46 inches in one hour at Palestine. Only a small portion of rains of such intensity can be absorbed, since if there is any colloidal content in the soil the surface quickly puddles and further absorption takes place slowly.[18] The Brazos River above Waco, with a drainage area of 30,000 square miles, bears more than 3,200,000 tons of soil a year.

The streams of this region, notwithstanding their high silt burdens and the possibility of poor foundations on which to erect dams on certain sites, present many excellent opportunities for water storage in their deep canyons, which in places spread out into broad basins; and nowhere would the results from water storage be of more benefit. Not only might storage result in preventing, or at least in lessening, the ravages of such floods as that which visited San Antonio, but it would furnish a great deal of power and water for irrigation in a section which is subject to long and costly droughts. It might be possible through such storage to irrigate a considerable portion of the Edwards Plateau region and thus add enormously to the value of these lands, the utility of which at present is largely restricted to grazing and that itself sometimes uncertain as during the drought of 1924. It would probably be necessary to make provision for flushing the silt from reservoirs by means of water stored in smaller reservoirs located above and constructed with this object in view, if this procedure should prove feasible. The woodland and herbaceous cover of this region is too light, on account of the limited rainfall, to protect the surface from erosion, but it is possible by adequate regulation of grazing, and by better protection of stream banks if not to reduce erosion at least to prevent its further increase. Range depletion as well as the maintenance of the protection of the cedar brakes requires careful investigation.

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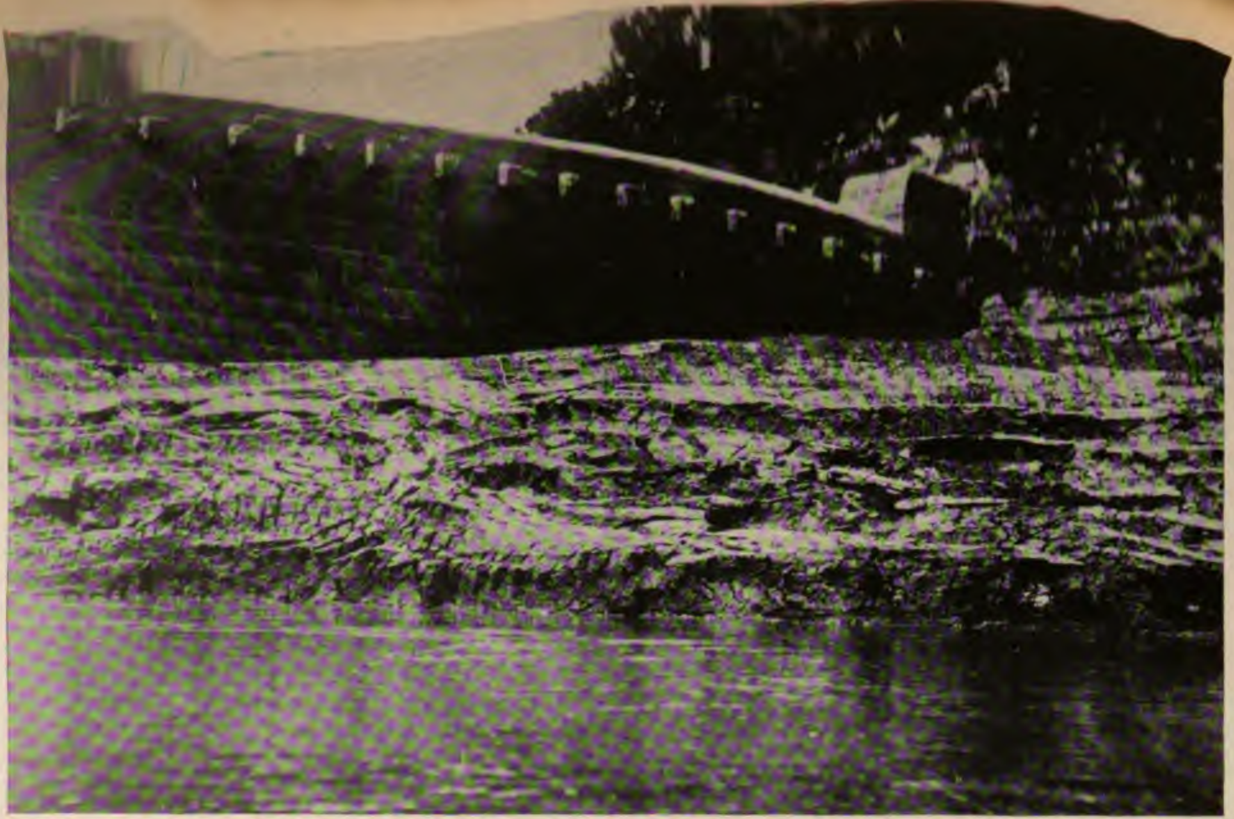
[18] See footnote 12 on p. 7.



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REMNANT OF SILT BED ABOVE DAM ON COLORADO RIVER AT AUSTIN, TEX.

The pondage of the reservoir was nearly destroyed after 10 years' service. The dam broke and a large portion of the silt was washed away. The silt burden of the Colorado River sometimes exceeds 5 per cent

FOREST INFLUENCES LOW, COLUMBIA RIVER WATERSHED

The snow fields of Mount Adams and Council Lake in foreground as feeders of Lewis River. Extensive areas of heavy forest protect the soil and limit erosion. The pale areas within the forest are burns

COLORADO RIVER AND GREAT BASIN

Two fundamentally different conditions are exemplified in the streams which drain the Colorado River basin. One condition is represented at the headwaters of the northern streams, the other in all the remaining portions of the basin.

The headwaters of the northern streams, in southwestern Wyoming and in Colorado, have their sources within the forested mountain slopes. They are partly fed by melting snows and are largely clear until they enter the Plains. The precipitation in the mountains, much of it in the form of snow, varies from 16 to 40 inches a year; on the Plains the yearly average rarely rises above 15 inches, being lowest in summer and highest between December and April.

The soils of the Plains are of many origins and vary in character but are prevailingly unconsolidated. The rainfall is too scant to support more than a growth of brush and chaparral or in places open woodland. The flood seasons of the northern streams are in the spring, in June, and in the fall. The spring and fall floods are due to rain, partly on the Plains; but the June floods, which are the highest, come from melting snows in the mountains. The early spring and autumn floods which result from rains, especially on the Plains with their scanty protection of vegetative cover, produce the greatest turbidity. The June floods, which are the highest, are not marked apparently by increase in silt burden. The rather limited record at Topock shows a stream of "only normal irregularity" approaching even the Columbia in evenness of flow. The relation of minimum run-off (January 4, 1925) to maximum (June 22, 1921) is as 1 to 92.

Forests are important in protecting these mountain head streams, in holding snow banks, in shading them and in retarding their melting. The absence of forests or even of adequate soil cover on the Plains, where the rainfall is insufficient to support such a growth, accounts for the high silt burden acquired by these streams in their passage through the Plains notwithstanding the prevailingly gentle topography.

The streams of the Great Basin and the southern tributaries of the Colorado River beginning with the San Juan have their sources either within the Plains or in low mountain ranges in Arizona, New Mexico, southern Colorado, Utah, and Nevada. Not only is the total precipitation which feeds these streams less, rarely rising above 20 inches and then only along the higher mountains, and with an average rainfall as low as 10 inches over much of the Plains and desert country, but very little of it is in the form of snow. Summer rains are the rule. Violent thunderstorms occur frequently, accompanied generally by high winds and sometimes by very concentrated precipitation. Great clouds of dust are usually carried by the wind in front of the storm. These heavy rains may alternate with long periods of drought. The Plains consequently have a scant vegetation of brush or chaparral and the areas of lowest rainfall are deserts with cactus as characteristic shrubby vegetation and very little grass cover. High temperatures over the lower-lying lands make a high evaporation factor and add to the irregularity of the run-off resulting from the sometimes concentrated rainfall. The Virgin River, which is a characteristic stream of this group, though "rising at an altitude of about 8,000 feet, soon drops into a sandy valley where it becomes a river of flowing sand. In ordinary stages it is very wide but very shallow rippling over the sand in tawny waves." Only an insignificant portion of the basins of these streams is really forested, so little that forests play a negligible rôle in affecting their regimen, which is determined by the heavy, irregular rains, the unconsolidated soils through which they flow, and the high summer temperature on the Plains.

At Yuma, below all of the important tributaries, the silt content of the Colorado River is estimated to average 7,000 parts per million and the total solid burden to amount yearly to 160,000,000 tons, of which less than 10,000,000 tons comes from the northern sources covering one-half of the basin and furnishing three-fourths of the discharge. Since the silt content is diluted by the smaller solid burden and larger volume of the northern sources " it shows that the lower Colorado River derives most of its enormous load of silt from the drainage area which includes the San Juan, the Paria, the Little Colorado, the Virgin, and the Gila Rivers," and that this silt comes from the region of unconsolidated soils with the scant cover of vegetation, limited precipitation consisting largely of rain which often falls in heavy showers. A rain of about 4 inches on September 17 and 18, 1923, over a portion of the basin of the Little Colorado caused an increase in discharge of the main Colorado from a normal of 10,000 feet per second to 110,000 feet per second. Except in the low mountains, which are only in part forest covered, the rainfall is too scant to support any general vegetative ground cover sufficiently dense to afford protection to the soil. Consequently erosion is active even where the rainfall is slight.

The potential horsepower of the Colorado River has been placed at 7,000,000, to be secured largely through the employment of 13 power sites and storage reservoirs on the main stream and the mountain-fed tributaries. The proposed Boulder Canyon Dam, at which the largest development would be obtained, would be 600 feet high and would impound 32,000,000 acre-feet of water, developing about 600,000 constant horsepower and 1,500,000 horsepower three-fourths of the time. The water, heavily laden with silt, would be desilted by sedimentation in the reservoir. (See footnote 11, p. 6.) Much of the water used for power purposes would also be available for irrigation, and the city of Los Angeles plans to use the desilted water as a source of municipal supply. It is estimated that the storage capacity of this reservoir would as a result of silting be largely destroyed within 150 years. Since the silt burden of the river at this point is often more than 2 per cent, the rate of shrinkage in storage capacity will probably be far more rapid than indicated by this estimate.

STREAMS OF THE SACRAMENTO AND SAN JOAQUIN BASINS

The streams of the Sacramento and San Joaquin Basins are subject to violent early spring freshets, originating in the heavy rains in the mountains; and their high silt burden has damaged the navigable estuary channels. The greater portion of the silt of these streams was formerly the result of hydraulic mining and even now much silt is derived from old tailings which are still in transit. California, like Colorado, has laws prohibiting contaminating streams with tailings and the necessary means have been taken to control this through settling beds. In spite of this control measure, however, the Sacramento River bears annually more than 2,250,000 tons of solid burden. Much of this is acquired in the foothills and plains, though considerable erosion takes place in the higher mountains and on the deforested region above Redding. Except at high altitudes much of the forest land has insufficient humus beneath the comparatively open stands of trees and there is within the forest a general absence of dense brush or of grass and of other herbaceous cover. This condition is far more prevalent in the mountains of the southern portion of the State than to the northward and at lower altitude than at higher. The rainfall even in the mountains toward the south is insufficient to support forests, the cover of the San Bernardino and other mountains in this section being largely open stands of brush. (Pl. 7.) Corrasion is active on the Tuolumne, the Stanislaus, and other streams of the Sierras which debouch into the Sacramento or the San Joaquin Rivers. This washing of stream banks is more or less constant, being a characteristic of streams coursing through unconsolidated soils or those deficient in cohesion, as are many of those of the California Basin. On the smallest tributaries this action might be lessened by protective planting.

Violent irregularities in the character of the precipitation, especially in the southern Sierras, add to the degrading influence of the streams, and make the lessening of erosion an important consideration. Although the general rainfall of California is light, 12 to 35 inches, one-half of it normally falls during three months—December, January, and February. In years of maximum precipitation the rainfall during this three-months' period will often equal or exceed that which would fall in the South Atlantic States during the same time. The rainfall of lower altitudes is frequently concentrated, and this is especially favorable for erosion. Only at the higher elevations is a large part of it snow, and its melting is often forced by a warm rain. The snow fields are found only at the highest altitudes,and even on Mount Shasta and Mount Whitney, although they do much toward sustaining stream flow during the dry season, they are not perennial, and except in gulches and north slope canyons, largely disappear after midsummer.

The functions of forest cover in limiting erosion are at an optimum at middle and lower altitudes in the Sierras of middle and southern California because of the character of the rainfall, which while sufficient to maintain a forest cover is irregular and frequently so concentrated that destructive erosion takes place wherever the soil is not adequately protected by a blanket of humus. South of the higher mountains and in the foothills, the lower rainfall and high evaporation factor preclude forest growth, or at best permit only the growth of thin, open stands of woodland with humus, so scant that it is rapidly dissipated through nitrification and there is a general absence of dense herbaceous and shrubby ground cover. In case the humus is destroyed grass does not form a sod. On the northern coast of California the conditions partake of those on the Columbia

River drainage, which are a heavier rainfall but more regularly distributed and not so concentrated and a lower evaporation factor. These are conditions which insure the formation of a dense sod wherever the humus cover is broken and there is sufficient light. Erosion consequently is not nearly so active in this region as in those portions of California where the rainfall is more irregular and where sod and dense herbaceous ground cover do not generally set on naked soil.

COLUMBIA RIVER AND THE EXTREME NORTHWEST

The precipitation near the northwest coast, which is the heaviest in the United States, reaches the maximum on the west slope of the Coast Range Mountains and chiefly affects small streams which drain directly into the ocean. Many of these are subject to high floods, especially during the winter and early spring, the seasons of heaviest precipitation. Notwithstanding the prevailingly porous and granular soils, a soil cover is necessary to prevent excessive erosion. When the timber is removed, most of these soils naturally set to sod and brush, but where this is not the case the protection afforded by forest cover with its prevailingly excellent humus is necessary to prevent erosion on the steeper mountain slopes. Notwithstanding the difference in the seasonal distribution of rainfall, the conditions closely resemble those of many of the tributaries of the Tennessee River which flow from the Smoky Mountains.

This, however, is not the case with the Columbia River, the salient feature of which is its clearness and the relative evenness of its flow, notwithstanding flood crests of 60 feet above low water. The streams which most closely resemble it in the United States are those of New England, but the flow of the Columbia is probably more uniform than that of any other large stream of the United States unless largely fed from lake storage. This condition is due to several causes: the prevailingly light character of the precipitation, especially over the Plains region where the soils are largely unconsolidated and to the covering of vegetation, largely brush and grass even on the plains; the granular character of the soils in the mountains; the large proportion of the run-off which comes from snow fields and glaciers and which takes place during midsummer, thus supplementing the run-off from rainfall which largely takes place during winter and spring, and which is rarely so concentrated as over the southern portion of the Great Basin, over the southern part of the Great Plains, and in New Mexico and Texas. There is also some lake storage on the Canadian drainage.

The heavy rainfall of the coast decreases on the eastern slopes of the Cascades and in the Plains areas is less than 15 inches, rising as the Rocky Mountains are approached to 20 inches and attaining in the mountains of northern Idaho and on the headwaters of the Clark Fork a maximum of 35 inches, and on the headwaters of the Lewis Fork a maximum of 30 inches. This precipitation is relatively slight, and it is of a character to render it available for soil absorption; also the prevailing surface conditions are highly favorable. The precipitation during the summer is extremely low compared with that during the winter, but is largely in the form of gentle showers, giving fullest opportunity for entire absorption with a very small amount of surface run-off. The winter snowfall is heavy, especially in the eastern mountains; and the deep snow banks in gulches and north hollows and where protected by the dense forest of conifers from sun and wind melt gradually during spring and summer, maintaining a steady stream flow. This not only compensates for the deficiency of the summer rains, but the absence of such rains is favorable, since they would accelerate the melting of the snow. The snow drifts and fields of the high peaks of the Cabinet, Coeur d'Alene, and Bitter Root Mountains, and of the Continental Divide sometimes last until reinforced by those of the succeeding winter. In the Williamette the snow-water flow is uninterrupted, for it is largely fed by the glaciers and perpetual snow fields of Mount Hood and Mount Jefferson, just as Lewis River is fed from the snow fields of Mount Adams. (Pl. 18.)

The torrential spring flood of the Northeastern States from the warm spring rains on the winter's snow, and the high, early summer flow of the streams of the Southwest from the rapid melting of the mountain snow under the high temperature of early summer, are both much reduced on the Columbia. The freshet season extends from May to July. The melting of snow in the mountains of Idaho and Montana is usually a gradual process, frequently occupying the entire summer. Rarely there may be accumulated snow in the forests and a late spring followed by very warm rains producing high floods such as those of 1826, 1854, and 1894. The northern tributaries are less erratic in their flow than the southern, and several lakes add to their stability of flow. Occasionally, however, a warm chinook wind will melt much of the snow during April, or even in March, causing high turbidity and floods on streams like the Clearwater and Lewis Fork. These winds, however, are exceptional and usually of short duration. The flood season, when the streams are very muddy, is usually two months later. The extension of cultivation has had little effect in increasing turbidity, since the cultivated lands are largely in the more level valleys and on account of the character of the precipitation.

Although the equable flow of these streams is primarily a result of the climatic conditions, the influence of the mountain forests is serviceable in protecting the snow from evaporation and lessening the rapidity of its melting. It is of greater value in checking erosion, notwithstanding the prevailing porous soils of the mountains, while the large amount of brush beneath the timber and the readiness with which grass, other herbage, and shrubs come in on naked soil are important factors.

On the Plains the rainfall is of such character, both in distribution and amount, that there is scant erosion. Although the silts of the Priest, the Pend Oreille, and other agricultural river valleys of the eastern headwaters of the Columbia are incoherent, the limited rainfall precludes the possibility of excessive erosion, unless at times of concentrated precipitation, a character of rainfall to which this region is seldom subjected. Should erosion of these soils take place, however, the placid portion of the Pend Oreille and other streams offer suitable situations for silting.

SUMMARY OF REGIONAL CONDITIONS

In the Northeast, in the region of the Great Lakes, and on the Columbia River, the silt burden of streams is on the whole negligible. There are no marked periods of extremely low water, disastrous floods are infrequent, and there is a low ratio of minimum to maximum flowage. The forest cover exercises little influence in determining the life of reservoirs.

The streams of the Middle Atlantic States, in spite of a wide margin between maximum and minimum discharge, have a much lower turbidity than those farther south. The drainage basins of many of them, however, are on sandy, shaley, or very permeable soils, especially at their headwaters, and for this reason erosion of soil proceeds at a comparatively slow rate even on denuded sites. Forests exercise a considerable protective function.

The streams of the Great Plains, and likewise the western Colorado River, flow through vast areas of unconsolidated soils on which, because of irregular and deficient rainfall, it is not possible in many places to maintain vegetative cover of sufficient density to obtain protection against erosion. Forest cover, however, exercises a high influence upon the headwaters of such of these streams as lie within the forested portions of the Rocky Mountains. The streams which have their headwaters in central Texas are in the same general class as those of the Great Plains. The rainfall, however, is more irregular, at times torrential, followed by long periods of scant precipitation. A consequence of this is extremely erratic flow of the rivers. The basins of these streams are largely covered with open parklike stands of trees, and there is a fairly good cover of grass, which in this region forms a more efficient protection than the scattered trees. A few areas of real forest occur, however, chiefly on the low mountains, and they should be carefully protected. On the whole, however, the protection afforded by forest cover is inconsequential.

It is in the Appalachian and adjacent Piedmont regions from Ohio and Maryland to northern Mississippi, and in the similar Ozark region of Missouri and Arkansas, in the mountains of middle and southern California, and on the slopes of the Rocky Mountains south of middle Colorado that forests seem to exercise their maximum influence in the protection of reservoirs. In these regions rainfall is irregular and often concentrated; soil where denuded erodes easily, contributing a high solid burden to streams; snowfall is light; and there is little lake storage. When forests are reestablished on such denuded lands, and reestablishment is readily effected, erosion of soil is largely checked.

Table 1 shows, for typical streams in different hydrographic regions of the United States, the comparative amount of turbidity, relation between maximum and minimum flow, and precipitation on the basin of the stream with maximum rainfall for each region.

TABLE 1.—*Flow and turbidity of typical streams of different sections of the United States*

	Area basin	Suspended matter	Average annual precipitation on basin [2]	Maximum rainfall for region [2]		Flow: Second-feet per square mile of drainage areas		Relation minimum to maximum flow
				Per day	Per month	Maximum	Minimum	
	Square miles	*Parts per million* [1]	*Inches*	*Inches*	*Inches*			
Northeast and Lakes regions: Connecticut	3,100	--------	42	8.31	17.55	18.5	[3]0.09	1 to 205
Middle Atlantic: Susquehanna	24,100	21	45	8.37	15.82	29.0	.09	1 to 322
Southeast: Savannah	7,294	142	62	22.22	35.49	42.5	.19	1 to 233
Texas Plateau: Colorado (of Texas)	34,200	351	32.5	23.98	25.87	7.0	.0003	1 to 18,000
Rocky Mountain, east slope: Missouri above Fort Benton	24,600	--------	24	--------	6.90	2.2	.09	1 to 24
Plains: Kansas at Lecompton	58,600	2,032	25	10.33	18.67	3.1	.0011	1 to 2,820
California: Sacramento	257	81	[4]78	9.68	71.54	62.0	.43	1 to 145
Northwest: Columbia	237,000	[5]40	45	7.66	20.14	5.0	[7].18	1 to 28
Interior Basin: Colorado:								
Colorado (Grand) [6]	26,200	720	26	--------	--------	4.6	.02	1 to 230
Gila at Yuma	71,000	5,000	16	--------	--------	[8]2.8	[9].00	--------

Connecticut, above Orford, N. H. (1904–1923): Maximum, March, 1913; minimum, September 28, 1908.

Susquehanna, above Harrisburg, Pa. (1889–1920): Maximum, June 2, 1889; minimum, September 28–29, 1900.

Savannah, above Augusta, Ga. (1884–1891): Maximum, 1888; minimum, October 16, 1904.[10]

Colorado, above Austin, Tex. (1898–1923): Maximum, April, 1900; minimum, August, 1918.[11]

Kansas, above Lecompton, Kans. (1899–1906): Maximum, May 31, 1903; minimum, March 6, 1902.[12]

Although the conditions of the Kansas at Lecompton are so unfavorable, on the headwaters of the Missouri River at Fort Benton, drainage area 24,600 square miles, the conditions are as follows: Maximum flow, 2.2 second-feet; minimum flow, 0.09 second-foot; relation, 1 to 24.[13]

Sacramento, above Castella, Calif. (1910–1920): Maximum, January 2, 1914; minimum, August 5 to September 21, 1920.[14] This is the fork of the Sacramento River which heads in the mountains.

Columbia, above The Dalles, Oreg. (1879–1919): Maximum, 1894; minimum, January, 1890.[15]

[1] U. S. Geological Survey.

[2] U. S. Weather Bureau.

[3] This low minimum evidently the result of artificial storage on preceding day.

[4] The rainfall given is that at Helen mine, the heaviest in the basin. The average rainfall for the basin is 23 inches.

[5] The material comes largely from the Idaho plains, which are treeless.

[6] For Grand, Green, and Gunnison above junction, since only scant figures are available for any one stream.

[7] 1925.

[8] June 22, 1916. This was chiefly from the Salt River, but no records on that stream.

[9] Dry for one or more months each year.

[10] NEWELL, F. H. RESULTS OF STREAM MEASUREMENTS. U. S. Geol. Survey Ann. Rpt. (1892–93) 14 (2): 148. 1894.

[11] GROVER, N. C., GRAY, G. A., and ELLSWORTH, C. E. SURFACE WATER SUPPLY OF THE UNITED STATES, 1918. PART VIII. WESTERN GULF OF MEXICO BASINS. U. S. Geol. Survey Water-Supply Paper 478: 29. 1922.

[12] KANSAS WATER COMMISSION. SURFACE WATERS OF KANSAS, 1895–1919. 463 p., illus. Topeka. 1921.

[13] GROVER, N. C., LAMB, W. A., and FOLLANSBEE, R. SURFACE WATER SUPPLY OF THE UNITED STATES, 1918. PART VI. MISSOURI RIVER BASIN. U. S. Geol. Survey Water-Supply Paper 476: 17. 1921.

[14] GROVER, N. C., McGLASHAN, H. D., and HENSHAW, F. F. SURFACE WATER SUPPLY OF THE UNITED STATES, 1919 AND 1920. PART XI. PACIFIC SLOPE BASINS IN CALIFORNIA. U. S. Geol. Survey Water-Supply Paper 511, 456 p., illus. 1923.

[15] PARKER, G. L., and LEE, L. SUMMARY OF HYDROMETRIC DATA IN WASHINGTON, 1878–1919. U. S. Geol. Survey Water-Supply Paper 492, 363 p., illus. 1923.

If the average quantities of suspended matter in the water and the wide ratios between maximum and minimum flow are used as a guide, the streams of the Plains region and those of Texas and the Southwest are more urgently in need of protection than those of any other group. The very conditions, however, which determine the wide fluctuations between maximum and minimum flow—that is, the extremely irregular rainfall and the long periods of drought broken by short periods of most concentrated precipitation (practically 24 inches having fallen in a single day in Texas, which is three-fourths of the precipitation for an average year)—make it difficult or even impossible to maintain a forest cover over those portions of the basins of these streams from which the turbidity is derived. In many places it is impossible to maintain a sufficient cover of shrubs and grasses to afford even a moderate protection against erosion of the soil.

It is significant that most of the turbidity of the streams of the Plains seems to come from below the mountains. As explained in the note to Table 1, the headwaters of the Missouri River show a most equable flowage as a mountain stream, the maximum flood flow being only 24 times the low-water flow. The regimen of the Missouri River as it emerges from the mountains is changed by the tributaries from the Plains. From these tributaries also comes the large burden of solid material which is borne by the Missouri in its lower reaches and which gives it the unenviable reputation of being one of our muddiest rivers, a stream which can well be compared to the Yellow River of China. The headwaters of streams which pass through the Plains but head within the mountains are materially benefited by protection; and all protective cover, whether of grass, brush, or forest, should be most carefully maintained.

At the other extreme from the rivers of the Plains, including those of Arizona and those of the southern portion of the Great Basin, are those of the Northeast, the Lakes region, including Wisconsin and Minnesota, and the extreme Northwest. The streams of these regions have a remarkably low turbidity and a low ratio of maximum to minimum flow. Reservoirs constructed for storage of storm water consequently have a long life. Not that protection is not desirable, even in the case of these streams, but of all our rivers, the streams of these sections most nearly approach the ideal in the eveness of their flow. The distribution of rainfall in these sections is such that there is little land which can not be protected by means of grass or forest cover.

The streams of the southern Appalachian and Piedmont region and those of California, seem to occupy an intermediate position. Normally they have moderate turbidity and have fairly even flow in comparison with the streams of the Plains and with those of Texas; but their flow is widely fluctuating when compared with the streams of the Northeast. The rainfall is periodically heavy, although sufficiently well distributed to maintain an ample forest cover for thorough protection. In the Appalachians more than 35 inches of rain have fallen within a month and in the mountains of California more than 71 inches within the same period. In both regions extremely concentrated precipitation frequently takes place, more than an inch sometimes falling within much less than an hour. The soils are such that, when they are denuded or exposed, erosion proceeds at a hight rate; but it is always possible to obtain thorough protection by forest or other cover, the forest being as a rule decidedly most efficient and preferable.

SUMMARY

On account of the wide fluctuations in the discharge of streams employed for the generation of power, especially hydroelectric developments, reservoirs are being located on their headwaters for the purpose of storing storm waters and thus equalizing the flow of the streams and obtaining a more thorough utilization of power.

If it were ascertained that the pondage of a reservoir located on a head stream was in danger of being materially reduced through erosion of soil from denuded land, it would be justifiable from an investment point of view to expend in the preservation of the storage capacity or in the extension of its life a sum of money which would not exceed the present value of the prolonged life of this storage capacity.

The acquisition of the denuded land on which erosion is most excessive and the planting of it to trees, not only offer means of greatly reducing the erosion, but promise returns from the investment so made. If such denuded lands can be acquired at a sufficiently low price, the returns from the growth of the timber may be expected to pay for the entire cost, with interest, of the land and its afforestation. Under some conditions the cost of the land and its afforestation would be so high that the growth of the timber would probably not return a current rate of interest on the investment. In such cases it would be economically desirable for the additional cost of the land and afforestation to be charged against the prolonged utility value of the reservoir. There would then be justification for expending in this way such a sum as would equal the present value of the prolonged life of the reservoir.

One of the most important considerations in determining the location of reservoirs for such a purpose is the life of the reservoir and the rate at which the initial pondage is lost through siltage due to erosion of soil.

The streams in the different parts of the United States may be grouped in relation to the quantity and irregularity of their runoff, their turbidity, and the value of forest cover in protecting their headwaters, and thus influencing the quantity of their solid burden.

In such a classification it appears that, because of the character of the soil, the rather small amount and even distribution of the precipitation, and the extensive storage of water in lakes and mountain snow fields, forests exercise a generally low influence in the Northeast, in the Lake regions and in the Northwest.

At the other extreme are the rivers of the Great Plains and Texas and the Colorado River. These streams flow through regions which, on account of the extreme irregularity and scantiness of the rainfall, are largely treeless or wooded only with scattered groves, and in consequence the influence of the forest cover is negligible.

There is an intermediate type of stream on whose watershed the forests do exercise a most important function in the protection of reservoirs. This type embraces the streams of the southern Appalachians, those of the southern Piedmont region, most of those that rise in the mountains of southern California, and the headwaters such of those as have their sources in the southern part of the Rocky Mountain system. They are within regions of irregular and usually heavy rainfall. Their headwaters at least are in forest regions. Wherever extensive areas have been denuded and exposed to concentrated rainfall, most of these streams have during floods high turbidity. If there have been no clearings on the headwaters of streams within these regions, or if the surface has not been denuded or exposed by fires, erosion is slight, there is a small quantity of solid burden, and silting threatens the capacity of storage reservoirs only to a slight degree. If there is excessive erosion due to soil exposure, it is possible to reestablish forest conditions and by doing so reduce erosion and lessen sedimentation.

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July 29, 1926

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FORESTS AND FLOODS

By Ward Shepard, *Forest Inspector, Branch of Public Relations, Forest Service*

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FOREWORD

By William B. Greeley, *Chief, Forest Service*

Now that the Mississippi floods have awakened us to the need for the most complete insurance possible against the recurrence of such catastrophes, it is essential that the true rôle of forests in flood control be recognized. Nothing will be gained by exaggerating the importance of that rôle. On the other hand, unless forests are permitted to play their part much will be lost.

Floods have been a common scourge of the world since legendary times. The Mississippi Valley experienced great overflows of water before its forests had been touched by an ax. Forests can not prevent floods in the face of heavy, long-continued rains or the rapid melting of masses of snow. To control the immense volumes of water suddenly flung upon the earth under such circumstances, in their rush to the sea, we must rely mainly upon the levee or reservoir or diversion channel.

But forests, well-sodded pastures, and terraced fields hold back more of the falling water and more of the soil than denuded woodlands, overgrazed hillsides, or eroded farms. This helpful influence can seldom be separated from the other factors affecting the flow of a stream so that it can be measured by itself in exact terms. It may be greater or less on a particular watershed, by reason of the soil, topography, or climate, but when exerted on all the watersheds of a great river basin it is enormous. Forests are better binders of the soil and better surface reservoirs of water than any other form of vegetation on the face of the earth; and the 160,000,000 acres of actual or potential forest land draining into the Mississippi have a real be presented at the appropriate of the comprehensive program of flood control in which engineering, forestry, and agriculture should all have a share.

FORESTS AND FLOODS

The Mississippi disaster of 1927 has thrown into bold relief the need for national foresight in dealing with the perpetual menace of floods. Levees, reservoirs, and other structures for holding or diverting water always have been and always will be primary means of flood control; but indispensable as engineering works are to the harnessing of flood crests, they should be backed up by measures to reduce floods at their source, through the restoration of forests and grasslands as soil and water holders and the protection of farm lands from soil washing and gullying.

Excessive rainfall and sudden thaws will always cause floods in rivers unprotected by large natural reservoirs like the Great Lakes. The best of forests can not prevent the discharge of water into stream beds. It can slow down that discharge, however, and absorb a portion of it. Forest cover can not prevent the geological process of erosion. But it can prevent excessive man-made erosion that follows denudation or neglect of the soil.

The excessive silt load carried by so many of our rivers comes from the washing away of topsoils under unskillful methods of farming and grazing, from the gullying of worn-out or abandoned hillside farms, and from the erosion of forest soils after destructive logging or fire. Injury or destruction of the vegetative cover, whether grass or forest, and of its spongy leaf litter and vegetable mold (fig. 1), accelerate the run-off of rain and snow water. In large portions of the Mississippi Valley, once clothed with dense forests, a slow, inconspicuous, but immensely significant process has been going on for decades—the deterioration of the vegetative cover, the loss of leaf litter and humus, and the laying bare of mineral soil. From an increasing area of relatively barren and impervious soil, rain flows ore swiftly and carries a greater load of silt that chokes river hannels and raises flood crests. Water runs off a tin roof faster han off a straw stack. A bucket half full of water will overflow if lled with mud. These illustrations, exaggerated as they are, picture hat happens on denuded and eroded slopes and in silt-laden streams.

The effect of the destruction of vegetation and humus seems insigificant on this or that acre, this or that farm, this or that stretch f woodland. But when we sum up the aggregate volume of erosion nd run-off in an immense catchment basin, like that of the Missisippi, and compare this volume with the size of the stream channel hat must carry the load of water and soil, we gain a new conception f the importance of surface conditions. Floods in large rivers begin s little drops of water and little grains of sand on millions of acres. very tree, every bush, every fallen leaf, every blade of grass, every contour furrow, every ounce of porous topsoil that impedes the progress of these drops of water and grains of sand toward the main channel relieves the lower river of some of its load.

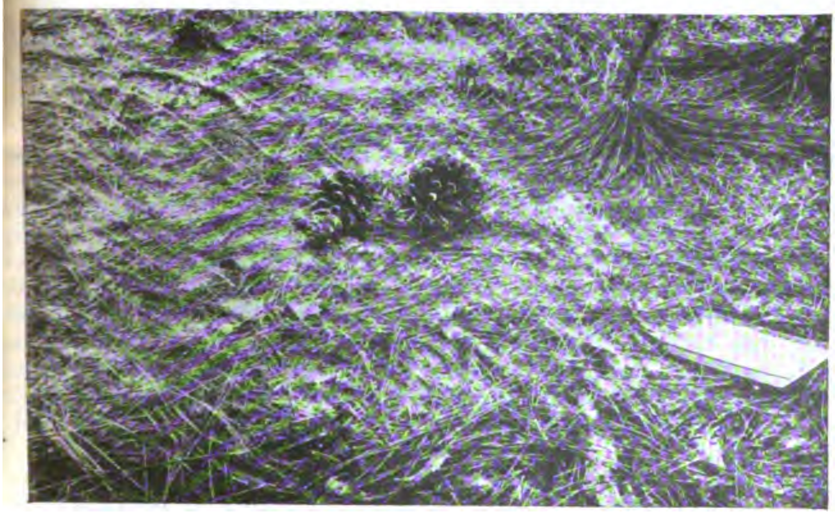

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FIG. 1.—In a well-kept forest the thick carpet of needles, leaves, twigs, and decaying wood protects the soil from erosion and acts as a sponge that carries rain water underground, where its passage to the springs and rivulets may require months. This delay prolongs and equalizes stream flow

The attack on floods should be a unified attack from the sources of the river to its mouth. There must be structures for controlling the water en masse, such as levees, reservoirs, and spillways; but the full measure of protection demands well-kept forests, grasslands, and fields to aid in controlling water before it is massed and concentrated. Proper use of the land surface of a great watershed will not only reduce the violence of floods but will protect the engineering works themselves from injury by heavy deposits of silt. It is even more important as a means of safeguarding life-giving soil from wastage and sterility. The best of all soil holders is the forest; it is the most absorptive form of vegetative cover; and it yields a crop adapted to the steeper and rougher lands where erosion and run-off are most rapid and a protective cover of the soil is most needed.

Forests are simply one of the influences affecting the behavior of streams, an influence which may be greater or less in the composite of all the conditions which have to do with the volume and rate of run-off. The precise effect that a given area of forest within a large watershed has upon the discharge into the river can not be determined because so many other factors influence the behavior of streams. One of these factors is the presence or absence of natural reservoirs in the form of lakes and swamps. The St. Lawrence, for instance, is regarded as one of the best-regulated rivers in the world because of the storage system afforded by the Great Lakes. Other factors are the steepness of the slopes, the porosity of the rock and soil, and the nature of the climate. The severity of the Mississippi flood in 1927, for example, was due to a climatic factor, heavy and long-continued rains in the lower portions of the valley. It would be fruitless and shortsighted to exaggerate the effect of forests upon river systems. They are simply one of the beneficial influences that can be brought into play.

The prevention of staggering losses of life and property from flood crests is the primary purpose of river control. But more than that is at stake. Holding soil in place and preserving its fertility, protecting bottom lands back on the small tributaries, and maintaining more regular flow in the feeder streams for the many resulting economic benefits are all objects that should be sought. For some of these protective purposes, forests and other forms of vegetative cover are the only possible means, and through their aggregate effect on all the feeder streams they have an ameliorating influence on the large floods in main rivers. Along with this protecting and ameliorating influence on water flow, forests more than pay their own way by producing marketable crops on land not fit for fields or pastures.

The following discussion of the influence of forests on run-off and erosion is drawn from experience and observations at many widely scattered points, and is designed to sketch a general picture of the relation of forests and other forms of surface protection to run-off and erosion in helping to provide flood protection.[1]

FOREST, SOIL, AND WATER

In building up a true conception of the influence of forests on a great river system one can best begin by drawing a simple picture of running water at work on a limited plot of ground, then enlarging this picture to cover minor valleys, and finally multiplying it a thousand or a million fold to attempt some measure of the immense cumulative effect of the destructive forces that are unleashed by abuse of the soil and its natural cover.

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[1] The following publications have been drawn upon for examples and data, and the reader is referred to them for more detailed discussions of forests, run-off, and erosion:

ASHE, W. W. FINANCIAL LIMITATION IN THE EMPLOYMENT OF FOREST COVER IN PROTECTING RESERVOIRS. U. S. Dept. Agr. Bul. 1430. 35 p. illus. 1926.

MUNNS, E. N. EROSION AND FLOOD PROBLEMS IN CALIFORNIA. Calif. State Bd. of For. Rpt. to legislature of 1921 on Senate Concurrent Res. No. 27.

ZON, RAPHAEL. FORESTS AND WATER IN THE LIGHT OF SCIENTIFIC INVESTIGATION. Final Rpt. Nat. Waterways Com., App. V. Sen. Doc. 469, 62d Cong., 2d sess. 1912. A reprint of this report may be obtained, as long as the supply lasts, by applying to the Forest Service, Washington, D. C.

THE FOREST AS A SOIL HOLDER

In watering a lawn one can see how the water trickles along the ground, collides with grass blades, splits up into tiny rivulets, spreads out slowly, and remains clear until it sinks into the soil. The same water falling on bare soil (unless it is absolutely level) gathers headway, collects rapidly in little rills and streams, and with its growing speed and concentration begins to tear loose the finer particles of soil, then sand, and, finally, gravel. Where its speed is checked, the turbid rivulet deposits its load; if it still gathers speed and volume it begins to cut a gully, its load of sand and gravel acting as an abrasive to cut faster and deeper.

This example shows in miniature how vegetation protects the soil and how the absence of vegetation permits soil to be easily carried away.[2] Vegetation hinders the flow of water, and by spreading it out takes away its force. Thus checked, it can not dislodge the soil particles, which, moreover, are bound together by the tangle of roots. Without vegetation there is nothing but the friction of the soil to keep water from following its inherent habit of going downhill as fast as it can. The cutting power of running water and its ability to transport soil increase greatly with increased speed. After the vegetative cover is removed, rain and sun compact the soil, each succeeding rain makes new gullies or deepens old ones, and the destructive combination of speed and concentration gains headway.

A well-kept forest is the best of natural soil holders. It has a dense ground cover of trees, shrubs, and lesser plants that impedes the flow of water. Tree roots spread far and wide to a depth of 2 feet or more, usually much deeper than the roots of grass or farm crops; and the roots of the lesser plants help to bind the topsoil together. On top of the ground is a mat of leaves or needles, twigs, branches, and dead grass and herbs, varying from a few inches to a foot or more in depth; and beneath this mat is the spongy woods mold or humus derived from the decay of generations of leaf fall. (Fig. 2.)

The canopy of leaves and branches breaks the force of rain and evaporates considerable quantities of it. The rain that penetrates the canopy has next to contend with the leaf litter, which retards the water in its flow over the surface, soaks up part of it, and passes part of it down to the humus and thence into the mineral soil. Also in their life processes, trees absorb large quantities of water from the ground and pass it off as vapor from their leaves. By these means the forest intercepts and evaporates a part of the rainfall, absorbs another part, and slows down the surface flow of the rest, retarding its speed and erosive action on the soil. Even in heavy rains the soil under a dense well-kept forest is little disturbed, and the streams that derive their water from such a forest are likely to remain clear.

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[2] A test made by the Missouri Agricultural Experiment Station showed that during six years erosion had removed soil at the rate of 208 tons per acre from bare uncultivated land, as compared with less than 2 tons per acre from similar land covered with bluegrass sod; in other words, one hundred and twenty-two times as much. See DULEY, F. L., and MILLER, M. F. EROSION AND SURFACE RUN-OFF UNDER DIFFERENT SOIL CONDITIONS. Mo. Agr. Expt. Sta. Res. Bul. 63. 1923.

THE FOREST AS A WATER HOLDER

The things that make the forest a good soil holder also make it a good water holder. During a rain the flow of surface water is retarded. More of it has a chance to sink down into the absorptive leaf litter, thence into the decayed leaf mold, and so down into the mineral soil and the fissures of the rocks. There it joins the great reservoir of underground water that feeds springs, brooks, and rivers. The deep, tangled root system of a well-kept forest also greatly aids this process of seepage, for water flows along living roots or through the tubes formed by decayed roots, far down into the soil.

Under ordinary conditions forest soils absorb from 20 to 50 per cent of light or moderate rains. Even in a prolonged rain the leaf mulch keeps feeding the water underground and thus empties and refills itself. In a violent or long-continued rain so much water may fall as to overtax this absorptive capacity, but even so, the forest has already reduced the run-off and continues to impede the remaining surface water in its progress to the stream beds. Such torrents as rush from bare, gullied land are rare in a forest, where during even a heavy rain one always has a sense of the dripping of water rather than of a rapid rush.

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FIG. 2.—A forest is the best vegetative cover for holding soil and water. The canopy of leaves and branches catches and evaporates a great deal of rain. What drips to the ground is impeded by the dense cover of shrubs, ferns, fallen leaves. and decaying wood, which absorbs much water underground, slows down the run-off, and keeps the soil from being washed into the streams

Underground storage of water by forests is an important natural means of regulating and equalizing stream flow. The immense quantity of water carried into the earth by the absorbent ground cover of a forest may percolate for months before it emerges.

Humus and leaf litter, while thus acting directly as an absorbent, also keep the soil itself mellow, porous, and more permeable. Forest soil is softer, lighter even than newly plowed loam. Forest humus does double duty to mankind. It leads water underground and it feeds the growing trees. It is a natural asset of incalculable value.

A forest has still other means of retarding run-off. Water and snow, falling on the leaves and branches of trees, are either evaporated or delayed in reaching the ground. The water evaporated may be as much as one-third of the total precipitation. More important, however, is the influence of forests in retarding snow melting. A well-stocked forest moderates the extremes of temperature; it is warmer in winter and cooler in summer than open land. As spring comes on, snow melting may begin earlier in the woods, but it usually lasts from four to eight times longer than on open ground. Moreover, as the mellow soil of a forest is likely to remain unfrozen or to freeze less deeply than soil in the open, it absorbs more of the snow water; soil in the open, freezing more freely and deeply during winter, permits snow water to rush off more rapidly into the streams. Spring freshets from melting snow are an important source of river floods. By delaying snow melting, feeding part of the snow water into the ground, and thus prolonging the period of run-off, forests tend to reduce flood crests and to equalize stream flow.

DEFORESTATION AND EROSION

Normal erosion is a geological process, and as long as water flows over the surface of the land it will continue its ceaseless work of carrying the mountains down to the sea. But with her kindly mantle of forest and grass nature protects the land from the gnawing tooth of running water, makes the soil fertile and life-giving, and restrains the levelling of the hills to an orderly and imperceptible process.[3]

Abnormal erosion as a man-made process is very different. When the soil-binding plant cover is broken, the earth is exposed to the insatiable cutting power of water. In this day of the steam shovel, one can easily observe abnormal erosion at work in fresh cuts, fills, and embankments. Until vegetation reclothes the soil, every violent rainstorm washes quantities of mud into the streets, sewers, and drainages; but from grass lawns near by only clear water flows.

Erosion can often be observed on abandoned farm land. If the ground is level, the insidious effects of "sheet" erosion are not very obvious; but if the ground slopes even a little the erosive action of water leaves a striking mark. Most of the water, instead of sinking in or trickling over the surface, rushes swiftly down the old furrows or makes little gullies of its own. Gathering speed and force, it rapidly cuts deeper and carries an ever-increasing load of soil.

In denuded or depleted forests[4] a similar but less obvious process goes on. It is less obvious because most denuded forests reestablish on the land a vegetative cover of some sort. But such areas, unless protected from fire and promptly restocked with young trees, lose much of their value as holders of water and soil. In the fire-swept denuded forest, the mineral soil, already scarred and broken by logging, becomes more and more exposed to the erosive force of water. (Fig. 3.) Fire consumes the logging débris and the protecting cover of leaf litter and humus, weakens and thins out the soil-binding grass and other vegetation, and by impoverishing the soil and exposing it to packing and drying reduces the chance of reestablishing a denser cover. Ravines are apt to form in the old logging roads. Gullies eat back into the bare slopes. The exposed surface is washed by every rain. A balance of nature that had existed for ages is overthrown and the soil of the hills takes its way to the sea. If fire is kept out, however, so that shrubs, briars, weeds, or young trees spring up in abundance, the natural protection from erosion afforded by a cover of forest may gradually be restored.

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[3] Normal erosion is described here in its most common and usual form. There are, of course, numerous instances of violent and destructive erosion, as in the case of cloudbursts or landslides, which are due wholly or primarily to natural causes.

[4] In this discussion, the terms "forest denudation" and "deforestation" are applied to methods of cutting timber, often accompanied by fire, which largely destroy a forest cover and prevent its replacement for a long period of time.

It is not necessary to remove all of a forest to accelerate erosion. Forests that have been repeatedly burned and badly thinned, but that are clothed with green foliage, may have the appearance of being uninjured. Even a fire that kills no mature trees almost uniformly destroys the underbrush, grass, and leaf mulch, and bares the mineral soil. Farm woodlands are frequently not only burned but overpastured. Such disturbances of the plant cover invite erosion in proportion to their intensity.

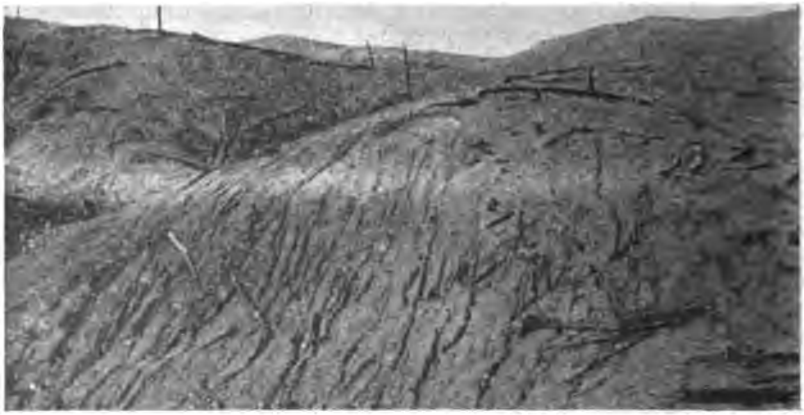

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FIG. 3.—When the forest is destroyed by logging or fire, the soil, no longer protected by the mat of decaying leaves and wood, is swiftly gullied by rains. Water rushes off the slopes in torrents, filling the streams and raising their flood crests with a heavy load of soil

A type of erosion that is hastened by deforestation is the caving of stream banks where trees have been cut away. The tangled roots of willows, alders, birches, cottonwoods, and other trees and shrubs growing along streams bind the soil of the banks and weaken the cutting power of the current. As a result, well-wooded streams usually flow in clean-cut, narrow channels, whereas deforested streams are apt to eat into the banks, wash the soil into the channel, and form a wide, shallow, meandering bed. (Fig. 4.)

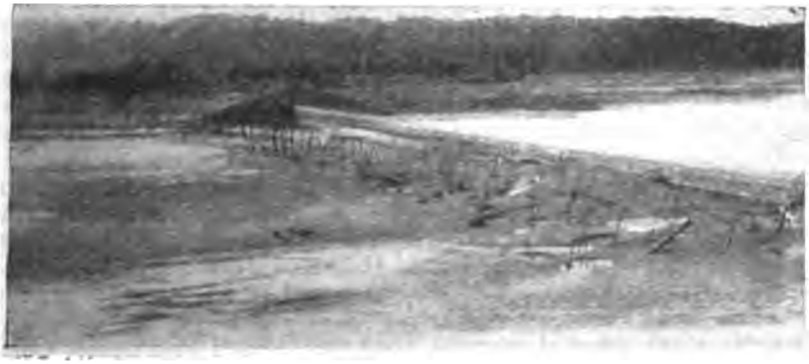
Erosion as a result of the destruction of vegetation cover is not confined to forests. In the grasslands of many portions of the Great Plains thinning and deterioration of the vegetation have been going on for decades. The cause is overgrazing, but the effects on soil and stream flow are essentially the same as the effects of deforestation, *though* less pronounced.

EXAMPLES OF EROSION

The striking increase of erosion on watersheds that have been deforested has been observed frequently both in America and in Europe. It can best be studied in small valleys, for there the contributing factors are more easily observed and weighed than in large drainages.

In 1913 fire destroyed the brush cover on a small branch of the Los Angeles River in the mountains of southern California. Careful study led to the conclusion that in the year following the fire 100,000 cubic yards of soil had been washed from an area of 1.2 square miles.

The soil that was washed from a burned hillside of 200 acres in San Diego County, Calif., buried a 12-acre alfalfa field so deeply that no signs of cultivation remained.



(Photo by Thorndyke Saville, North Carolina, Geological and Economic Survey)

FIG. 4.—The evil of soil erosion extends down to the main streams, where it clogs the channels, cuts down the carrying capacity, and impairs flood-control works. This reservoir, formed by a 38-foot dam built as recently as 1910, has been made useless by silt. Top soil to the amount of 126,000,000,000 pounds is swept into our rivers each year from poorly handled farms, grazing lands, and forests

On a tributary of the Sacramento River, where vegetation was killed by smelter fumes, as much as 400 cubic yards of soil per acre has since been removed by erosion.

A flood in a deforested canyon in California carried from twenty to forty times as much sediment as the coresponding freshet in an adjoining forested canyon, and continued muddy after the other streams had cleared.

The effects of denudation of grasslands at high altitudes in the Wasatch Mountains of Utah have been studied by the Forest Service. On a small, badly overgrazed watershed, rainfall, run-off, and erosion were accurately measured for a number of years. Grazing was then excluded and the vegetation allowed to increase to about two and one-half times its previous density. This increase in density decreased erosion by 56 per cent. One storm in the first period washed down 2,354 cubic feet of sediment; a storm of equal intensity and greater duration in the later period washed down only 845 cubic feet of sediment.

Similar examples of erosion following denudation could be cited from other parts of the United States, particularly the southern Appalachian Mountains, and from many other parts of the world. Such erosion has been especially severe in parts of France, Italy, Spain, Greece, Asia Minor, and China.

DEFORESTATION AND RUN-OFF

The swift run-off that follows forest destruction raises the flood level with silt, gravel, and bowlders. It also raises the flood level with an excess burden of water that would under normal conditions be absorbed into the ground. The reduction of this surplus burden of silt and water is a prime objective of flood control.

The influence of deforestation in speeding up run-off has been accurately observed and measured in small valleys. One of the most famous of these experiments was carried on for many years at Emmenthal, in Switzerland, where the run-off from two small valleys, one completely forested, the other only partially forested, was measured and compared. It was found that the stream from the completely forested valley was more uniform in its flow and carried less débris than the other stream. After very heavy rainfall of brief duration the forested stream carried only from a half to a third as much water as the partially forested stream. In the summer the forested stream kept up a higher and more regular flow.

The burning of the brush cover in a small canyon in southern California has already been mentioned. After a heavy rain the following winter the run-off from this canyon exceeded that from any other stream which experienced the same storm. Its flood peak reached the unprecedented flow of 700 second-feet per square mile of catchment area.

Several years ago a disastrous flood was caused at Pueblo, Colo., by local cloud-bursts. In canyons that had been largely denuded, the crest of the flood occurred six hours after the beginning of the storm. In the forested canyons the flood crest occurred from 18 to 48 hours after the beginning of the storm and caused much less damage.

That such effects come in part from destroying the absorptive capacity of the forest floor is shown by experiments made by the Forest Service in the mountains of southern California. Within three years after the brush cover on a canyon drainage was destroyed by fire the soil had lost 45 per cent of its water-absorbing power. This loss was due partly to the burning of the litter and humus and partly to the rapid erosion of the topsoil.

The Missouri Agricultural Experiment Station has shown that over a period of six years nearly half the rain falling on a plot of bare uncultivated soil ran directly off into the streams, whereas only a little more than one-tenth of the rainfall ran directly off similar soil covered with bluegrass sod.

In the Forest Service experiments in the Wasatch Mountains an increase of two and one-half times in the density of the grass cover decreased the surface run-off 55 per cent, even though at its densest the grass was less than half of a full cover. From one storm during the early period of scanty cover the surface run-off from the small watershed under observation amounted to more than 15,000 cubic feet; whereas in the later period of denser cover, from a storm of greater duration but equal intensity, the surface run-off was less than 6,000 cubic feet, or 39 per cent as much.

The influence of deforestation in drying up springs is widely established by authoritative examples both in America and in Europe. Springs form a striking and common evidence of the presence of underground water, which is the principal contribution of forests in equalizing and prolonging the flow of streams. The disappearance of springs after deforestation is ordinarily proof that rainfall has run more rapidly from the denuded surface instead of sinking into the ground.

CUMULATIVE EFFECTS OF DEFORESTATION ON LARGE RIVERS

The examples cited indicate the effects of deforestation on small watersheds. It is frequently asserted that deforestation has no influence on large rivers because great floods occurred before the forests had been touched by the ax. At the opposite extreme, it is asserted that floods are due primarily to deforestation. It is necessary to use moderation and common sense in approaching this problem. Forests can not prevent the great floods that come from heavy, long continued, widespread rains, especially when combined with the rapid melting of snow. On the other hand, both common-sense observation and careful study have shown that forests may reduce the violence of floods and erosion not only in small watersheds but in large river systems.

The difficulty of "proving the case" by exact measurement arises in part from the impossibility of weighing each of the complex factors that influence the behavior of a large river, such as varying conditions of soil, slope, vegetation, cultivation, and climate as well as natural storage in lakes, swamps, and overflow lands. In the absence of exact quantitative proof, we find it difficult to visualize the cumulative influence of thousands of square miles of distant and perhaps scattered forests on the main river channel where the flood rages. When we visualize the forest, we think of an acre or a few acres, and we ask how such a limited surface reservoir can have any measurable effect on the giant flood that is bursting the dikes of the river. How much can it hold back from the torrent? What relation can its steadily flowing springs, rivulets, and brooks have to the great flood?

The answer is to be found in the vast extent of the forest reservoir as compared to the relatively narrow channel in which the mightiest river is confined, especially if it has been pinched between levees. It is like an enormous roof drained by a single waterspout. The forests of a great river basin constitute, it is true, only a shallow reservoir but one that may make up for its shallowness by its extent. If these forests are in good condition, they hold the soil in place; they carry a large proportion of their water underground, pay it out slowly through springs and rivulets, and thus hold back the flood stages of countless brooks, creeks, and little rivers. Now, it is precisely these springs and rivulets, brooks and small rivers that feed the main rivers. From direct rainfall on their surface and from the run-off of their immediate banks the large rivers receive only an insignificant fraction of their water. The greatest rivers and the most violent floods merely collect and concentrate in one channel the individual contributions of innumerable minor and individually unimportant streams. And these minor streams are in turn merely collectors of water from the vast unchanneled surfaces they drain. On these surfaces the potential rivers and floods fall as drops of water whose cumulative effect depends on the speed they gather on their way to the sea. The physical condition of every square foot of the great aggregate of these land surfaces determines in some measure whether run-off is to be held back or speeded up, and it is here that an important key to flood reduction is found; for vegetative cover, if vigorous and dense, checks water as it falls and while it is still spread in harmless quantities over great areas. During this period, while water is "mobilizing" for its assault on main-stream channels and before it has concentrated in large masses and attained dangerous speed, vegetative cover may exert a decisive influence on flood stages by capturing a considerable part of the water and holding it back even if for only a short period. (Fig. 5.)

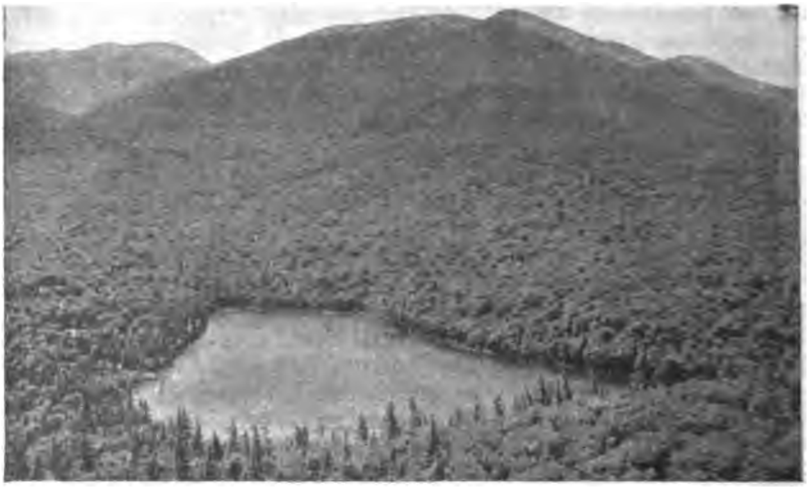

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FIG. 5.—The forest is only a shallow reservoir; its power lies in its vast extent. The amount of water and soil that any acre of forest holds back from the stream seems insignificant when we think of a great flood. But we must multiply that acre by millions to get some conception of the importance of forest cover on a great river basin

The relative effect of forests or other vegetative cover may be greater or less in comparison with the many other factors influencing the speed with which rainfall concentrates in the major river channels. It is relatively unimportant in regions composed of sand plains and gravel beds or strewn with lakes and swamps. It is much more important in regions of steep topography and impermeable soils. The examples cited of the effects of deforestation on small streams are drawn from regions with soils and topography of the latter kind. Similar results on a larger scale necessarily follow the destruction of forest cover on extensive watersheds with similar soil and topography.

We are not forced even here, however, to rely on speculation or theory. There is ample testimony from Europe, from Asia, and from America that large rivers have markedly changed their habits and that this change has been for the most part in the direction of higher and more violent floods, of lower water in dry seasons, and of the choking of channels with débris. This testimony is not made up of the vague impressions of old men. It is confirmed by the study and observation of scientists and engineers, and has been an object of interest to scientific academies, engineering congresses, governments, and parliaments in various countries.

In the absence of marked climatic or geological changes, the cause of these disturbances of river flow can be ascribed only to changes in surface conditions that increase surface run-off and erosion. In modern times the most striking change that man has wrought over great areas of the earth's surface is the destruction of forests. This destruction has been extremely rapid in the United States during the last 50 years. In recent decades, with the rising value of timber, destructive lumbering has advanced far into rough, mountainous country, where the effects of denudation are most severe. It must be then that the widely attested deterioration of large rivers is related to the deterioration of the forests that once densely clothed their slopes and headwaters, though other factors have, of course, been brought into play, like the augmentation of run-off through the ditching and tiling of wet lands.

Let us examine a little of the evidence. M. O. Leighton, chief hydrographer of the United States Geological Survey, made a careful study of flood and rainfall records for the period 1885 to 1907 on the Ohio River and three of its tributaries, on the Wateree, the Savannah, the Tennessee, and the Alabama Rivers in the South, and on the Connecticut River in New England. The method used was to determine for each year the number of days of flood stage in proportion to precipitation.[5] The most marked change was found on the Ohio, whose flood stages in proportion to precipitation increased from 0.38 in the period 1885–1895 to 1.48 in the period 1896–1907. All the rivers studied showed an increase of flood stages. A specially intensive study of the Tennessee River over a 24-year period showed that flood stages in the latter half of the period, compared with the number of days of rainstorms heavy enough to produce floods, increased nearly 20 per cent.

A survey and historical study of the Delaware River between Trenton, N. J., and Easton, Pa., showed that previous to 1835 floods of 14 feet at Lambertville had been recorded only three times, whereas after 1835 floods of that height became common and in at least three instances exceeded that height by a third to a half.

An investigation, the results of which were published in 1899, showed that the Genesee River, in New York, whose watershed was entirely deforested, had a maximum rate of flow three times as great as that of the Hudson, whose watershed was 90 per cent forested, and a minimum rate of flow only about one-fourth as great. In other words, its flood stages were violent and its low water stages abnormally depressed.

The effects of erosion in silting large river channels have been even more widely observed. Only a few examples will be cited.

The amount of sediment carried by the Susquehanna River had become so great by 1871 that the Brewerton Channel to Baltimore was obstructed and had to be abandoned.

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[5] C. F. Marvin, Chief of the Weather Bureau, states that this method does not take into account certain factors influencing floods, namely, the duration of precipitation and its local distribution, as well as the intervals of one or more days between consecutive heavy rainstorms during flood periods.

Forty years ago the Coldwater River, in Mississippi, was regularly navigated by large boats, which loaded cotton at the town of Coldwater. Mud flats and sand bars have closed this portion of the river to navigation.

The Tennessee River carries an annual silt burden of 11,000,000 tons; yet some of its heavily forested head streams carry only a trace of silt even in high water. The Tennessee gathers its soil burden mainly from deforested and agricultural lands.

Numerous examples could be cited from Europe. A government survey of the River Po showed that floods had steadily increased in height for a century. The Loire was formerly much used for navigation. Now it is no longer navigable above Saumur. Its bed is choked with sediment and in summer is only a great stretch of sand. After a storm or a sudden thaw "every depression in the ground gathers a torrent, every ravine confines a river, and all these waters, accumulating in the valley of the Loire, form a roaring sea." The forests of the Loire watershed have been reduced until they cover only 13 per cent of its area.

The effects of rapid run-off and erosion, multiplying as the headwaters converge, extend downstream into the large rivers, increasing their burden of water and detritus, concentrating their task of transportation into a shorter period, and decreasing the capacity of the channels by silting.

Silting has another important bearing on floods; it is a menace to the engineering works used in river control. Silting reduces the storage capacity of reservoirs built for flood retention and may ultimately fill them. The reduction of erosion simplifies the flood-control problem from whatever angle we view it.

SOIL WASTAGE

Although this discussion deals primarily with forest land, a brief consideration of farm and grasslands will round out the conception of rational land use as a part of a comprehensive plan for the control of floods, and it will be of timely interest to consider such a plan chiefly on the basis of the history and condition of the grasslands, farming areas, and forest lands of the Mississippi Basin.

WESTERN GRAZING LANDS

The Mississippi receives about one-sixth of its flow of water from the eastern slopes of the Rocky Mountains and the Great Plains. The headwaters of these tributaries are mainly clear, for they are partly forested and are fed chiefly by springs and melting snow. But on their course through the plains they are subject to violent fluctuations between high and low water stages, their banks suffer constant undercutting, and their meandering channels are clogged with silt and sand bars. The Missouri River above Ruegg, Mo., carries a yearly load of 176,000,000 tons of silt.

In the drainage basins of these western tributaries there are 25,000,000 acres of unreserved public domain, on which the Government has allowed free and unrestricted grazing. Excessive grazing on many areas has impaired the ground cover in quality and density. An experiment made by the Forest Service on open grasslands in Utah showed that the run-off from rainstorms on overgrazed land was seven times as great as that on moderately grazed lands. In the national forests, grazing control has as one of its aims the reduction of erosion and flood discharge. The Secretary of the Interior has recommended that similar grazing control be extended to the unreserved public domain. Building up the herbaceous cover in order to armeliorate floods and silting is an important phase of grazing control.

FARM LANDS

The erosion of cultivated farms and pastures is going on in the United States at an alarming rate. From hundreds of thousands of acres in western Kentucky, Tennessee, and Mississippi, northeastern Kansas, and other hilly regions, the best soil has been carried away. A survey of one county in the Piedmont region revealed over 90,000 acres of once productive land degraded to gullies and bare rock. In the central Appalachians it is estimated that 50 per cent of the cleared land has been seriously damaged by erosion. On the steeper slopes, many old fields have been washed down to bedrock or sterile subsoil. In many parts of the country thin soil overlying bedrock has been ruined or impoverished by poor cultivation.

This wastage of life-giving plant food by the "sheet" erosion of our best soils and by the unwise cultivation of steep slopes is a direct economic loss of incalculable magnitude. Our present concern, however, is with its effects on stream flow. This immense burden of silt has had a large part in clogging river channels and adding to the height of floods. Its removal has exposed the less permeable subsoil and speeded up the rate of run-off, a vital factor in floods.

The cure of this evil can come only from such measures as terracing, contour plowing, careful pasturing, the improvement of farm woodlands, and planting steep, denuded slopes to trees or grass. As one soils expert has expressed it, some soils "melt like sugar" when cleared, even on gentle slopes, and should never be cleared at all. Slopes of easily eroded soils should be kept in forest or pasture. The encouragement of such protective measures is a matter for the agricultural experts of the Federal and State Governments.

FOREST LAND

The clearing of forests for cultivation is an inevitable part of advancing civilization. No one could object to the hewing of farms from the primeval wilderness. But such purposeful clearing must be distinguished from the denudation that results from fire or destructive lumbering and burdens the Nation with large quantities of idle or half-productive forest land not needed or used for farming.

Up to about 1880 the need for more farm land in the United States kept pace with forest destruction. Then, with the expansion of lumbering, forest destruction began rapidly to outpace the rate at which the cleared land could be used for farms. All told about 200,000,000 acres of forest land has been cleared primarily for tillage and about 75,000,000 acres more of land logged for its timber has been converted into fields. But in addition a vast area of logged-off land, estimated at over 330,000,000 acres, has never been put under the plow or has been abandoned after a period of cultivation. Most of this land is either too rough or too sterile for farming. Of this cut-over area some 80,000,000 acres is now classed as denuded land, with little or no forest cover; while the rest bears culled forest, second growth, or young trees and sprouts, often inferior in quality and in the density of the stand.

Forest destruction is not an inevitable part of lumbering, although one has largely gone with the other in the United States. It results from the removal of timber with no provision for replacement, from neglect of cut-over land, and particularly from repeated fires in slashings and logged-off areas. The practice of forestry, on the other hand, often removes but a portion of the timber, leaving the smaller trees for further growth; or, if clean cutting is advisable, insures prompt reforestation through natural seeding or planting.

The harvesting of timber under practicable methods often requires a temporary impairment of the water-holding capacity of a forest, but this is speedily restored if reforestation is prompt and vigorous. The forestry policies of Europe long have recognized the need for "protection forests" on high, steep mountain slopes forming the headwaters of important rivers. Cutting in such forests is conducted with extreme care or not permitted at all in order to avoid impairing the effectiveness of the forest cover for retarding run-off and erosion. The ownership and maintenance of protection forests are commonly regarded in the Old World as public functions; and the same conception has been carried into the purposes and administration of national forests in the United States. It is one of the objects sought by the Weeks Act of 1911 for protecting the headwaters of navigable streams.

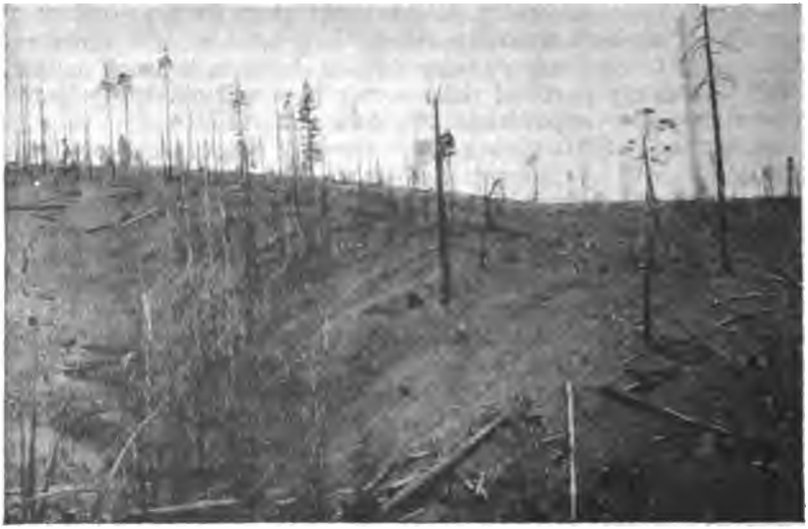

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FIG. 6.—The clearing of fertile lands for farms has been inevitable and desirable. Forest denudation is a different story. In the United States we have about 80,000,000 acres of denuded forest unsuited to agriculture and over 200,000,000 acres of second-growth forest, much of it inferior and poorly cared for. Very little of this land is rendering its full service in timber growing, water storage, or soil holding. The first step in forest rehabilitation is universal protection against fire

Much of our second-growth forest is deteriorating by reason of repeated fires and the cutting of smaller and smaller timber. Notwithstanding the progress that has been made in farm forestry and industrial forestry, especially in protecting woodlands from fire, a large part of our forests come nowhere near exerting to the full their potential power for timber growing, soil holding, or water absorption. If our forest lands are to render their full economic service, including soil and water conservation, they must be devoted to more intensive timber culture. Also much of the abandoned and marginal farm land, which is now a drag on agriculture, must be converted to forest.

Though much of the forest in the Mississippi Basin was inevitably cleared for farms, there remain extensive areas of forest land, widely varying in cover and condition, that have a bearing on the flood problem. The most important of these areas will be briefly considered.

MINNESOTA AND WISCONSIN FORESTS

Minnesota and Wisconsin contain the headwaters of the Mississippi. Erosion in most of this region is not an important factor. The Mississippi River above Minneapolis has a silt burden only one-fiftieth as great as that of the Tennessee River. Much of the soil is sand and gravel, which absorb water readily even after the forest cover is destroyed. Moreover, the land is level or gently sloping; and the headwaters of the Mississippi have an extensive lake and swamp system, with a large capacity for storing flood waters.

From many of the timbered swamps the forests have been cut and the water drained to obtain farm land. Many of these swamps have peat soil, and after drainage dry out to great depths and are very susceptible to fire. Swamp drainage in this region has not always been successful as an agricultural enterprise and has destroyed potential flood storage. Many swamps and overflow lands should be kept in forest for the double function of storing flood waters and producing such timber as they can grow. A third public service can often be rendered by them as breeding grounds for fish, waterfowl, and fur-bearing animals.

WOODLANDS OF THE CENTRAL FARMING REGION

From southern Minnesota and Wisconsin south through the central farming region there is a large aggregate of woodland, mainly in farm wood lots and in the rough and broken country that slopes down to the river channels. Studies made in Iowa showed that even small wood lots in a prairie region help decidedly in absorbing water into the soil. The wood-lot soils were found to contain more water than soils of similar character and slope on the open prairie or in cultivated fields. The forest cover on rough lands bordering streams, great and small, has in the aggregate an important bearing on erosion and stream flow.

These scattered woodlands of the central farming region are often in poor condition. They are apt to be thinned out by haphazard culling of timber, by overgrazing and trampling, and—particularly in the southern portion of the region—by frequent "woods burning." The agricultural character of this region precludes the extension of forests on any scale sufficient to materially influence the discharge of its streams. Yet every acre of existing woodland or of poor land that might advantageously be planted with trees can be made to contribute its mite to the solution of the problem we are dealing with.

RIVER BOTTOM FORESTS

Before the advent of agriculture, the forested overflow lands of the Mississippi and of some of its main tributaries were nature's storage reservoirs in times of flood. The floods, spreading far and wide through the tangled forests, lost some of the power which in later years has been concentrated between levees. The reclamation of the rich alluvial bottom lands was inevitable, but there is a question whether it may not have gone too far. Congress has appropriated funds for the purchase of about 260,000 acres of Mississippi bottom lands for the creation of the Upper Mississippi Wild Life and Fish Refuge. It is probable that in some places the value of overflow lands for storage, timber growing, game production, and recreation exceeds their value for agriculture. The feasibility of public acquisition of such lands for forests and wild-life refuges should be considered in the plan of flood control.

ROCKY MOUNTAIN FORESTS

The Missouri River, which with its numerous large tributaries is one of the principal feeders of the Mississippi, drains considerable portions of the eastern slopes of the Rocky Mountains. Fortunately much of the headwaters of these streams is embraced within national forests, which are managed not only for timber growing but for stream protection. Some further consolidations of the national holdings should be made, either by purchase or by exchanging Government timber for land. Here as elsewhere in rugged, mountainous country, public ownership is the surest safeguard against forest destruction and injury to watersheds.

On the western tributaries of the Mississippi, grasslands constitute a large part of the drainage, and the maintenance of their vegetative cover, as explained elsewhere, is a factor in flood control.

OZARK FORESTS

The Ozark Plateau and the Ouachita Mountains occupy an extensive stretch of country on the lower drainage of the Missouri and Arkansas Rivers and on the headwaters of the Ouachita, all important tributaries of the Mississippi. In the past, land in this region was cleared, farmed for a few years, and then abandoned and the process repeated somewhere else. The acreage treated in this fashion was large. The protection value of the remaining forests of the Ozarks has been materially reduced by lumbering, fire, and overgrazing, which have thinned out the timber and held down the ground cover. In the southern part of the region nearly a million acres of land are included within national forests, a portion of which has been purchased under the policy for protecting the headwaters of navigable streams.

These hills and mountains represent one of the key areas where forestry on a large scale can aid in reducing the Mississippi floods.

They form a natural forest region, containing but a small proportion of agricultural land. They are the only area within the drainage of the Missouri and Arkansas Rivers—aside from the extreme headwaters in the Rocky Mountains—where forest cover can materially influence the run-off, for the watersheds of these great rivers are primarily prairie and farm lands.

ALLEGHENY AND SOUTHERN APPALACHIAN FORESTS

The western slopes and plateaus of the Alleghenies and southern Appalachians contain the headwaters of such important tributaries of the Mississippi as the Ohio, the Tennessee, the Cumberland, and the Kentucky Rivers, which furnish to the great river nearly half its water supply. Among the forest regions influencing the run-off of the Mississippi Basin, the Appalachian and Allegheny Mountains are of primary importance.

Much of the soil of this region is close-textured and nonporous. Snowfall is light, and precipitation is often concentrated in torrential downpours. There is but little natural storage in the form of lakes and swamps. Water runs rapidly from the steep slopes, swiftly eroding cut-over or abandoned land. It is primarily the forest that holds the balance against the force of running water on mountain slopes. In such a region forest cover exerts its greatest influence on stream-flow and erosion. (Fig. 7.)

With the introduction of logging railroads, lumbering was extended into all but the very roughest parts of the mountains. The old-growth timber has now been reduced to one-third its original extent. Fire has still further impaired the cover of vegetation and leaf litter. In addition to denudation by logging and fire, there has been extensive clearing of slope lands for farms. Since about 1880 many hill farms have been abandoned, owing to the movement of the rural population to the towns and cities, and the land has largely been ruined by erosion.

These various forms of denudation have already caused irreparable damage. The Federal Government, recognizing the great importance of these mountain forests for stream protection as well as for timber growing, has gradually been purchasing lands for national forests under the Weeks Act. From Pennsylvania southward the Government has to date bought almost 2,000,000 acres in the Alleghenies and southern Appalachians. There is obvious need for more public forest ownership in a mountainous region bearing such a vital relation to the Mississippi River.

A FORESTRY PROGRAM FOR THE MISSISSIPPI BASIN

If forests are to contribute their utmost in any reasonable time toward the solution of the Mississippi flood problem, it is essential that forest protection, forest restoration, and public forest ownership be speeded up. It is short sighted to brush forestry aside on the ground that immediate flood relief is needed and that forest restoration takes time. Forestry is supplementary to immediate measures for flood relief—it is not a substitute for them. One of the functions of government is to take a long look ahead on problems of such profound significance to national welfare. Besides, the time element in forestry is easy to exaggerate. The reclamation of denuded lands by tree planting and the protection of existing forests can make themselves felt in better watershed conditions within a few years. Nature, if given half a chance, is prolific and energetic in restoring thinned-out and even denuded woodlands.

The main essentials of a forest program for the Mississippi Basin are as follows:

A large extension of public forest ownership, especially in the critically important mountainous and rough lands.

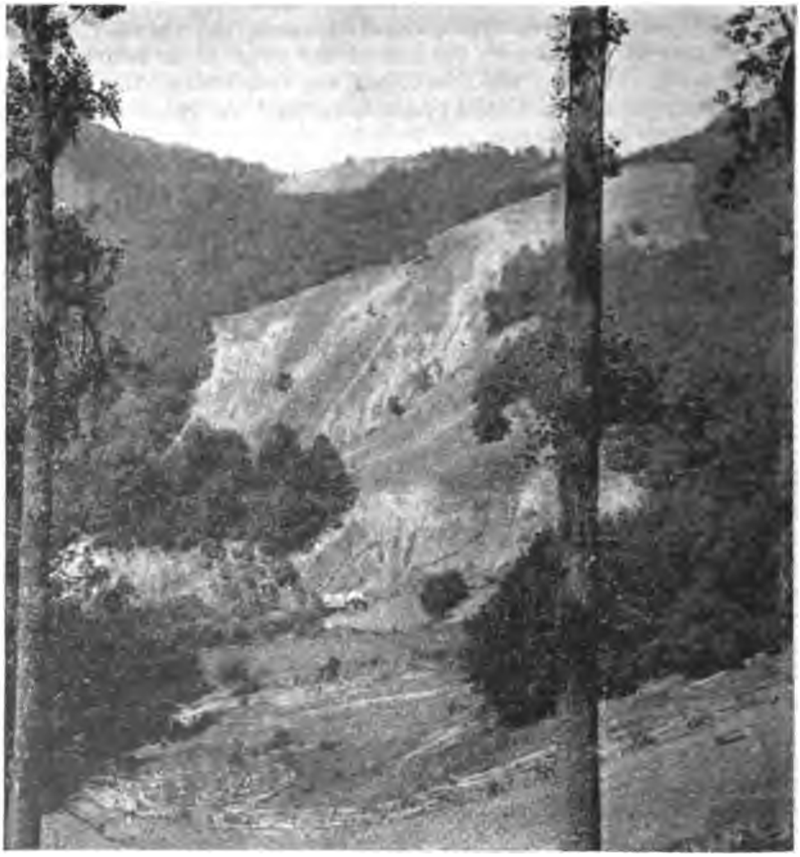

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FIG. 7.—In the conflict between running water and the soil of steep slopes, the forest holds the balance of power. Once this balance is destroyed, soil and water rush streamward. To prevent the destruction of mountain forests by logging or clearing, public ownership is essential. The most important tributaries of the Mississippi River have their headwaters in the Appalachian and Rocky Mountains, which should be kept forever forested

Thorough protection of all forests against fire.

More tree planting.

Public assistance in the better handling of woodlands, especially through research and educational work.

PUBLIC FOREST OWNERSHIP

Laws already exist under which land for national forests may be purchased anywhere in the drainages of navigable rivers. The Government has established and is extending national forests on watersheds within the Mississippi Basin. The present program of public forests should, however, be greatly enlarged and should be shared in by the States. The areas in the Mississippi Basin where protection forests are important, especially the Allegheny, Appalachian, and Ozark regions, should be accurately determined and an acquisition program formulated and apportioned by agreement between the Federal Government and the States. Public forests will pay good dividends in timber growing and in permanent forest industries; but wholly aside from these returns, public ownership is particularly urgent on lands subject to severe erosion and rapid run-off.

European experience has amply proved that mountain forests of high protective value do not safely lend themselves to private ownership, even under economic conditions favorable to timber growing. Public ownership of such forests is the only assured way to protect the headwaters of streams. The great bulk of the mountain forests in the Rockies and in the Sierra Nevada and Cascade Ranges of the Pacific States are in national forests. Probably 80 or 85 per cent of the main mountain ranges of the East should remain in forest; and to assure anywhere near this percentage, public forest ownership must be greatly enlarged.

Other types of protection forest should also come under public ownership. The denudation of swamp forests is often an invitation to ill-advised drainage of lands unsuited to agriculture but of great importance in water storage. Such swamps should be owned by the public. Overflow lands along the main river bottoms may also in many cases have a greater utility for water storage than for farming and may thus be better adapted to public than to private ownership. In order to reduce the silting of detention and storage reservoirs, their immediate watersheds should as far as possible be forested, a condition that can best be assured by public ownership.

FOREST-FIRE PROTECTION

Under the Clarke-McNary Act, the Federal Government cooperates with States and landowners in promoting better care of private forests, which constitute 80 per cent of our total forest area. The principal means employed is cooperative fire protection. The total cost of the protection of forest lands contemplated by this law is estimated at $10,000,000 annually. At present the three cooperating agencies are contributing only about $4,000,000, or two-fifths of the required amount. Over half of the 36 coöperating States are wholly or partly within the Mississippi Basin, but a large part of the forest land in the basin still receives little or no protection from recurring fires.

The rapid increase of cooperative fire protection under this law and its predecessor, the Weeks Act, has demonstrated during 16 years the practicability of Federal aid in forest protection as the first step toward better forest conditions. The chief needs in its further development are more adequate appropriations by the public agencies and the further extension of organized protection by the

States and owners. Of the private forests of the country, which constitute by far the larger part of all our forests, only about one-half receive any protection from fires.

There is no question that increased protection against fire will reflect itself rapidly in denser forest cover and in reduced erosion and run-off. Twenty years of protection in the western national forests has led to a marked improvement of large areas of mountain forests. Young trees have sprung up in the openings; and grass, herbaceous plants, and shrubs have become more vigorous and form a denser cover. Similar results have been achieved in many State and private forests.

TREE PLANTING

In the aggregate the farms of the Mississippi Basin contain an immense amount of poor, rough, or steep land, as well as denuded stream banks, that should be planted to forest. Farmers can seldom afford to do such planting unless they can obtain cheap planting stock. To meet this need the Clarke-McNary Act authorized Federal cooperation with the States in growing and distributing planting stock to farmers. All told the 32 cooperating States are producing about 60,000,000 trees a year, of which about half are set out on farms. To accomplish the purpose of this law there is need to increase greatly the size and capacity of State forest nurseries so that their output of trees can keep pace with the demand. There is need also for interesting more farmers in the benefits of forest planting and for extending this cooperative work to commercial timberlands. The present rate of forest planting, encouraging as it is, is but a snail's pace considered from the standpoint of the great areas of waste land in this country.

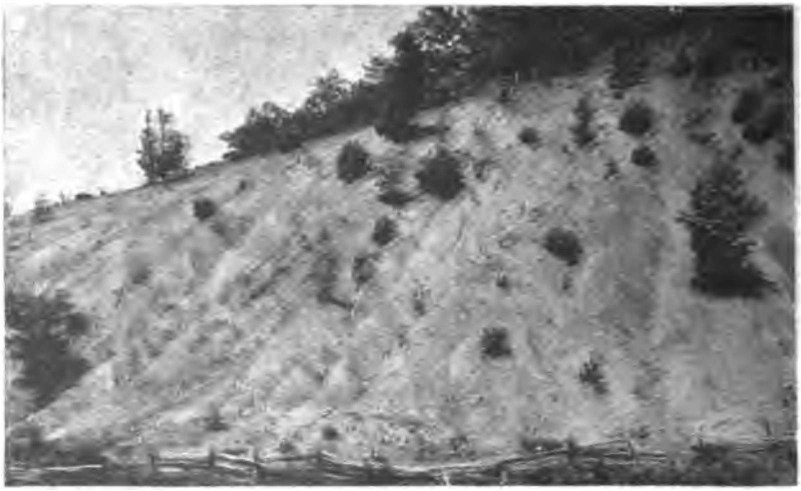

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FIG. 8.—There is much rough, steep land in farms that should be planted with trees to hold back soil and water. Tree planting will make idle forest land productive

PUBLIC ASSISTANCE IN BETTER HANDLING OF PRIVATE WOODLANDS

Many denuded lands must be planted if they are to have a forest cover. But most forests, unless completely denuded and burned out, will improve rapidly without artificial planting if given a chance. Recognizing this fact, the Clarke-McNary Act emphasized fire protection as the most important means of encouraging forest restoration. It provided also for cooperation with farmers in managing and improving woodlands. This cooperation should be extended to commercial forests, which are even more subject to deterioration and destruction than farm woodlands.

The entire Mississippi Basin is now included in the territory covered by Federal forest experiment stations. By furnishing basic knowledge on timber culture, these stations will be of great assistance in the management of both public and private forests, but there is need for more active effort by the Federal Government and the States to cooperate with private owners in getting this knowledge into effect.

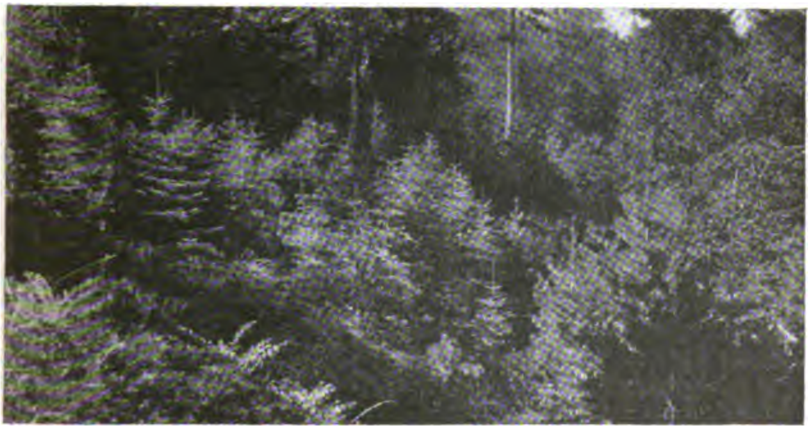

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FIG. 9.—Forest improvement does not require a lifetime. Good fire protection will rapidly mend most of our depleted forests. The national-forest land shown in the picture was logged 20 years ago. Conservative logging methods and subsequent protection have produced a sturdy young forest

SUMMARY

There are two chief lines of attack upon floods: First and most imperative, the construction of levees, storage reservoirs, and other engineering works to cope with water concentrated in great masses in main river channels; second and supplementary, the maintenance of dense vegetative cover, the terracing of farm lands, contour plowing, and other measures for keeping the land surface that is drained by the river system in condition to check run-off of rain water while it is spread harmlessly over the surface and before it attains mass and speed in stream channels.

Vigorous, dense vegetation (especially grass and forest) is one of the principal means of maintaining good surface conditions.

Of the various forms of vegetative cover, the well-kept forest is the best water and soil holder. The deep leaf litter and humus of the forest absorb large quantities of water into underground channels, whence it seeps slowly into springs and brooks. Even in winter the forest soil remains more absorptive because it freezes less freely and deeply. Forests prolong the melting of snow several weeks after it has disappeared from the open. Forests can not prevent high water after lengthy rainfall or sudden thaws; but even under such circumstances they diminish the volume and prolong the time of the flood run-off, thus tending to reduce its crest.

The forest, by slowing down run-off, by laying a thick mat of litter over the ground, and by binding the soil with a dense tangle of roots, also slows down erosion. The degree of erosion depends on the speed at which water runs off the surface and the extent to which it is allowed to work directly on the bare soil.

The beneficial effects of forest cover in retarding run-off and erosion have been established by authoritative observation and experiment in many parts of the world. Compared with a deep reservoir, the water-storing capacity of the forest is small. But in a great river basin the cumulative effect of vast areas of well-kept forest in holding back water from concentrating too rapidly in the one channel through which it must escape to the sea is of great importance in flood control. The forest is a shallow reservoir, but it makes up for its shallowness by the vastness of its extent.

Surface conditions in the Mississippi Basin have been profoundly altered by agriculture, lumbering, and grazing. Much of the sloping farm land has been cultivated without terracing or contour plowing, much of the grassland in the Great Plains region and elsewhere has been depleted by overgrazing, and much of the forest has been impaired or largely destroyed by careless logging and fire. From vast areas of improperly handled or denuded lands water has rushed more rapidly into the streams, carrying millions of tons of our richest topsoils, clogging river channels and reservoirs with silt, and causing violent and destructive floods.

Forests have been impaired or destroyed on many millions of acres of land entirely unsuited to agriculture. Forest rehabilitation on such lands is an essential means of restoring vigorous vegetative cover in the Mississippi Basin. Especially important are the forests on the Appalachian, Ozark, and Rocky Mountain tributaries of the Mississippi; for it is on mountain slopes that forest cover is most important. Forested swamps and river bottoms are also valuable for the storage of flood waters.

In order to get the maximum benefits of forest cover in the Mississippi Basin, it is essential that public ownership of forests, especially in the mountains and swamps, be greatly extended; that cooperation in forest-fire protection between the Federal Government, the States, and private owners be increased; and that the Government and States give more assistance to farmers and timberland owners in forest planting and better forest management.

Engineering works are a primary essential in flood control, but vigorous, well-kept forests will supplement and protect them. The two methods of control should be developed together, a river being treated as a unit from source to mouth.

The prudent use of forest land, like the prudent use of farm and grazing land, pays its own way, and the gain to flood control is a by-product without cost.

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FLOODS FORESTS AND THE FUTURE

Published and distributed by
THE AMERICAN TREE ASSOCIATION
Washington, D.C.

DEPARTMENT OF COMMERCE
Office of the Secretary
WASHINGTON

July 7, 1927.

Mr. Charles Lathrop Pack,
American Tree Association,
1214 16th St. N.W.,
Washington, D. C.:

Dear Mr. Pack:

I have your letter of July 1st and convey below my sentiments on trees:

"I am in favor of trees; also of reforestation. The floods of the Mississippi might be ameliorated by it but reforestation is of far greater importance than that, and in any event they cannot wait for trees to grow up even if this were a contributory remedy. But in any event, I am for the trees."

Yours faithfully,

HERBERT HOOVER.

HH-AGS

FLOODS
FORESTS
AND THE
FUTURE

Published by
THE AMERICAN TREE ASSOCIATION
WASHINGTON, D. C.

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SHALL WE PREVENT FLOODS?

By CHARLES LATHROP PACK

President, American Tree Association

IT IS time to act.

In carrying forward all great human endeavors there is a time for taking thought, a time for formulating plans, and a time for action. Without the last the first two are sterile.

Today we are confronted with the tragic aftermath of one of the most gigantic defeats that engineering science has ever suffered. A great river arising in its angry wrath has broken our man-made levees as a summer's shower carries away the mud toys of a little child. For forty years engineers have told us to put faith in levees. For forty years, in spite of failure after failure, we have put not only faith, but money. Probably we shall have to devote many millions more to this form of river development, but it is folly longer to depend for flood protection on levees alone.

The Problem Huge

The problem of the Mississippi is far too huge and too inextricably bound up with our national welfare to approach from anything less than a national viewpoint. It is a problem to whose solution we must bring not only the best of engineering skill, but also the best knowledge and scientific attainment in the fields of forestry, range control, and soils management. We have got to formulate a vast, thoroughly correlated scheme wherein the engineer, the forester, and other experts shall give their best toward devising effective means of taming once for all the turbulent Father of Waters.

Here in America, and for the past twenty years especially, there has been a great deal of loose thinking and irresponsible writing about the influence of forests on stream flow. It would be futile for even the most skeptical longer to maintain that a forest cover is without important effect on surface run-off, erosion and the regimen of rivers. Such gross misstatements are amply refuted by history, by scientific investigation, and by common sense.

Among the older nations of the world many a costly lesson has taught both European foresters and engineers that the problem of flood control is a dual problem in which engineering and forest culture must go hand in hand. In the Karst, Greece, Palestine, southern France, and Italy the importance of forests has made itself manifest in unforgettable ways. In the French Alps, in the Swiss Alps, and in the Tyrol, the laborious, painstaking measures to bring back the land to forest speak with sincere eloquence of the importance these countries place on the rôle of trees in flood control. Fundamentally the value of engineering control methods depends upon how well the eroding tributaries are protected by a forest cover.

Already a wealth of forest facts exists pointing to the moderating action of forests on floods and to the deterring effect on erosion. And, after all, it is erosion that furnishes arms and ammunition to flood waters. Not water, but solid matter, is the destructive stuff that floods are made of.

Solution of Problem

The utility of forests, then, need not be dwelt on here. Others have gone into this field with convincing thoroughness. I think it more appropriate at this time to suggest a plan and to make a plea for action. My plea in the first place is for federal and state acquisition of land for forestry purposes, especially in the Appalachian region. A large percentage of the water that flows past New Orleans comes from the combined sources of the Ohio, Tennessee, and Cumberland Rivers. These three rivers are the chief flood breeders of the Mississippi. All arise among the steep slopes and heavy soils of the Appalachians. From this area enormous quantities of silt are torn annually to add to the volume and destructiveness of the lower river in flood stages. Here, if anywhere, is the region where land should be acquired and put under forest management by the Federal Government and by the states. In this section more than any other, forests can make their greatest contribution as ameliorating factors in flood control. Yet the rate at which land for this purpose is being purchased there is pitifully incommensurate with the need.

At the northern headwaters of the Mississippi the topography is gentle and the soil more sandy or gravelly. Little silting occurs there and, excep for a few localities, little erosion. However, the headwaters of the Mississippi River, with literally innumerable lakes and forested swamps, are the great natural reservoir of this river. Indiscriminate drainage of the swamps and even of lakes and the destruction of the forests around the lakes tend to destroy this natural reservoir. The northern portions of Minnesota and Wisconsin are but little suitable for agriculture. Here, if the land is protected from fire, nature will keep the source of the Mississippi clothed with forest vegetation. Therefore, fire protection of the forests on the headwaters of the river is essential, both as a measure of flood control and as an economic necessity.

From the western tributaries the lands just east of the Rockies are undergoing a tremendous process of sheet erosion as the result of unrestricted sheep grazing. For this country the solution lies largely in a rational system of range control until forage plants again cover the land and hold the soil in place.

Capable of Returns

So it is in the Appalachians, and to a somewhat less extent in the Ozarks, that forestry can best contribute its share toward the control of the Mississippi. Today probably less than 2 per cent of these regions receives any form of forest management. Federal ownership and state ownership is the immediate solution, the first step towards translating these wasting assets, these potential forces of destruction, into acres of perpetual productivity. The need is already established. A scientific personnel to carry on the work already exists. The legislative machinery has been provided. All that remains to complete this program is for Congress to appropriate the money. And the money needed will be but a very modest part of the millions destined for flood control in all its various phases before the last word is said.

It is important, too, that we remember the money so spent must not be looked on in the same light as money for levees or spillways—funds purely and simply spent in flood control and bringing no other return than protection. Even so, it would be worth every cent. But these forests, federal and state, are themselves capable of important monetary returns. As the years pass they should pay back into their treasuries every penny expended in acquiring them. They will furnish perpetually renewable sources of wealth to coming generations. And all this they can do while they are fulfilling their great primary purpose of holding the soil in place, reducing erosion, and mitigating the destructive effects of floods.

There has been reason enough why the Federal Government should acquire forest lands and why the state forest departments should embark on a program of state forest acquisition. Good economic and social reasons. Floods, with their increasing severity and toll, serve to give point to this need and to emphasize the importance of carrying out this program of acquisition without delay. A government's first reason for existence is to protect its people from disaster. It cannot evade the moral and economic obligation of using every possible means for preventing repetitions of the Mississippi tragedy. I have not the slightest doubt that the Government will meet the issue squarely and adequately, but delays are costly. Forests are not planted in a day. Neither do their full benefits become apparent within the first decade.

Delays Are Costly

It may be a long, hard, uphill pull. But with our American genius for organization and with the body of scientific knowledge that forestry has acquired within the last twenty years, there can be no good reason for delaying a program of acquiring Protection Forests by government and by state.

The problem of flood control seems to me to require a three-part solution.

First, I should plead for a restoration to forest conditions of all those portions of the land suited for practical forest growing that are today destructively and wastefully washing away through lack of trees.

Second, the application of the very best engineering technique we possess for the building of levees, storage dams, spillways, or, if need be, a combination of all these.

Third, we need to correct and regulate the destructive grazing that causes millions of acres east of the Rockies to erode and flow away.

The Mississippi has brought to us an obligation for action that must be squarely and immediately met. How else shall we justify our stewardship to the generations that follow?

DO FORESTS PREVENT FLOODS?

By RAPHAEL ZON

Director, Lake States Forest Experiment Station

(Reprinted from "American Forests and Forest Life," the magazine of the American Forestry Association)

ONE often hears mentioned forest destruction as one of the chief causes of floods. The flood in the Mississippi Valley is one of the great disasters in our history. At such a time there must be no room for professional partisanship, and the people have a right to demand, from the forester and engineer alike, a frank and dispassionate analysis of the facts. What, then, are the facts?

Floods, such as the country is now experiencing, take place when there are excessively heavy or long-continued rains or rapid melting of snow, or both, over a large part of the river valley. Soils covered with forests can store up a quantity of water corresponding to a precipitation of 0.16 inch, or, in very favorable conditions, 0.24 inch at most. A cover of moss can store up from 0.18 to 0.39 inch of water. Moss can absorb water amounting to from 200 to 900 times its weight; dead leaves of birch, maple or other hardwoods 150 to 220 times their weight, and pine needles from 120 to 135 times. These amounts are insignificant when compared to the enormous quantities of precipitation that cause excessive floods. Over 22 inches of rain fell in twenty-four consecutive hours at some points in the storm of July, 1916, in the Blue Ridge of North Carolina that inundated the French Broad, Catawba and other river basins and caused destruction estimated in the millions of dollars. A torrential rainfall of 14 inches within a short period was recorded this spring in the lower Mississippi Valley. Such enormous quantities of water are utterly beyond the capacity of the forest floor to absorb. Very soon after a heavy rainfall and often during the precipitation which may precede it, the forest floor becomes so completely saturated with water that it allows any further rain to pass off, just as it would from open ground. It is evident that, under exceptional meteorological conditions, the capacity of the forest floor to store water must fail.

The forests themselves could not have held back these raging waters, but without forest management there can be no rational river management.

Such exceptional meteorological conditions existed over a large portion of the Mississippi watershed during last fall and this spring. After a wet fall, which saturated the ground, there came in the northern portions a very heavy winter snowfall. The melting of the snow in the spring, over ground already saturated with water in the northern parts of the watershed, combined with heavy rains, at times torrential in character, in the middle and lower parts of the Mississippi Valley, caused the present terrible floods. Under such conditions, if the entire Mississippi watershed were densely covered with forests, flood conditions could not have been prevented. Whether they would be as excessive and disastrous in their consequences is another question.

That high floods occurred on the Mississippi River long before logging operations on a large scale began in the northern states is a matter of record. The fact that forests do not prevent floods resulting from exceptional meteorological conditions, is not saying, by any means, that forests have no effect upon water stages in our rivers, or that they are an insignificant factor that can be overlooked in any comprehensive plan for flood control by either storage reservoirs, levees or any other engineering works.

Is it necessary for this country to experience such calamities as this in order to learn the simple lesson that water, like fire, must be controlled at the start?

It is a hopeless task to connect up statistically the disappearance of our forests in the northern states, with the frequency and severity of floods in the Mississippi River basin. Flood statistics are extremely meager in this country. If there are records of the dates when they occurred, no other accurate records existed at that time of the condition of the cover in the basins.

In this country there are about 287 rivers which are classed as navigable. Of these scarcely 25 per cent have any kind of coextensive records of precipitation and stream measurements covering periods of more than fifteen years, let alone records of the vegetative cover.

Deductions made from deficient data secured in limited regions have often been generalized as applying to all rivers, climates and conditions. In order to bring out the true relation between forest cover and stream flow, the conditions must be studied separately for each stream. The effect of forest on stream flow is different in different climates. It varies with the abundance, character and distribution of the precipitation, and with temperature. In regions with severe weather, abundant snowfall and sudden springs, all other conditions being equal, the effect is greater than in humid climates with prolonged drizzling rains. On steep, impermeable soils, the effect of the forest is greatest. On deep, sandy soils, it may be insignificant.

Most of the studies of stream flow so far made have been confined to large river basins of many thousand square miles. On such there exist many conditions of soil, topography and vegetative cover, which counteract each other and obscure the relation that may exist between the behavior of the stream and forest vegetation.

It is futile to draw conclusions as to the effect of forests upon flood stages by observations on the lower portions of large rivers. Yet that is exactly what has been done in most cases. These are misleading, since the water stages at the lower portions of these rivers are the result of the diverse conditions prevailing on the various tributaries.

Any attempt to base conclusions about the effect of forests upon floods upon inexact observations of stream flow leads only to groundless speculation, lengthy arguments and confusion. A striking example of this is given by the Tiber, which, with the exception of the Nile, perhaps, is the most historic of rivers. It has so far proved impossible to ascertain whether the floods of the Tiber have increased or diminished in the course of centuries, owing to the fact that the incomplete records lend themselves to conflicting conclusions.

It has long been recognized in the older countries that the secret of permanent flood control lies at the source rather than the mouth of mountain streams.

When we turn, however, from large to small watersheds, the forest as a controlling factor in stream behavior comes out in unmistakable bold relief. If forests cannot prevent great floods in large river basins, they can and do prevent small floods in small watersheds. Accurate records, continued for a long period of years, of the effect of forested and deforested watersheds upon the behavior of streams are available for many countries, including the United States. They are particularly abundant in Switzerland, and the French, Italian and Tyrol Alps. This effect has now been so universally recognized that such countries as Switzerland and France have adopted as a definite policy, involving large expenditures of money, the control of mountain streams by means of reforestation. It has become a recognized principle in the older countries that in order to bring a river system under permanent control, the work must start, not at the mouth but at its source, and be confined chiefly to the reestablishment of a forest cover at the headwaters of the stream.

It is not so much the storage of water in the forest floor that gives forests such a prominent part in the regulation of stream flow as their ability to prevent erosion. The forest is the most effective agent for protecting the soil from erosion, because (1) the resistance of the soil to erosive action is increased by the roots of the trees which hold the soil firmly in place, and (2) at the same time the erosive force of the run-off is itself reduced because the rate of its flow is checked and its distribution over the surface equalized.

The forest protects the soil from erosion. Erosion clogs streams, cuts down their carrying capacity and increases flood danger and flood destruction.

Erosion has a most important bearing upon the height of flood waters in the rivers, since the sediment carried by the rivers and the coarser detritus brought down by smaller streams often increase stream volume to such an extent that the height of the water is raised far beyond the point it would reach if it came free from the detritus and sediment. When the channel of the stream has become filled with waste material, even a slight rainfall will cause a flood, while, if the channel were deep, it would have no perceptible influence upon the height of the water in the stream. Streams flowing from deforested watersheds are capable of carrying enormous quantities of detritus. The famous French engineer, Demontzey, computed that one mountain torrent brought down, after one storm, in 85,000 cubic yards of water over 221,000 cubic yards of detritus, or more than 2½ times its own volume.

L. C. Glenn, who made a special study of the erosion in the southern Appalachian region, ascribes the increase in the height and violence of floods in the mountain streams of the southern Appalachians to the denudation of the steep mountain slopes and the consequent erosion. When floods are small and gentle, the deposits in the plains consist of fine alluvium. When the floods are great and violent, the deposits consist of coarse sand, cobbles and boulders. In the past the flood-plain deposits of such southern rivers as the Watauga, the Doe, the French Broad, the Catawba and the Yadkin were built of fine sandy loamy clay. In the last two decades, however, the deposits have grown coarser, which points to the prevalence of high and violent floods.

The increasing amount of sediment carried by our streams is one of the chief factors contributing to the increasing flood danger. Since of all vegetable covers, forests are most efficient in preventing the slopes from eroding and the beds of streams from filling with silt, they are an important factor in flood control.

In the light of all these facts, one cannot escape the conviction that the cutting away and burning of the forest on the western slopes of the Appalachians, where the Ohio and its tributaries rise, increased erosion from the slopes, raised the water level in the tributaries and increased the flood danger farther down the Mississippi. Likewise, breaking up the virgin sod of the plains, cutting away the timber along the banks of the streams in the West, draining the swamps and even some of the lakes of the North, the construction of a network of ditches and sewers following in the wake of settlement and city development, all have thrown a greatly increased flood burden on the lower portions of the Mississippi Valley.

The more serious part of it is that erosion, once started, has a tendency to grow worse. If soil erosion, either from denuded forest slopes or cultivated fields, is not stopped, there is little likelihood that floods will ever be controlled. As H. H. Bennett, of the United States Bureau of Soils, states: "There are no hillside terraces north of the Arkansas River. Eighteen inches of top soil have been removed from the youthful fields in some parts of northeastern Kansas. The entire top soil is gone from hundreds of thousands of acres in western Virginia, western Pennsylvania, eastern Kentucky and southeastern Ohio. From these lands rain water courses much faster to the Mississippi than formerly.

"Trees, grass, woodlots, forests and other soil-binding and soil-building crops will vastly improve the flood situation. Not only will they slow up the run-off water, but they will save the most valuable part of the soil and will reduce the clogging of streams, which cuts down their carrying capacity and adds to the flood danger."

France, as well as a number of the older countries, has adopted as a definite policy the control of mountain streams by reforestation.

The forest vegetation on the steeper slopes of the watersheds could not prevent flood conditions resulting from exceptional sudden accumulations of water on the watershed. Their destruction, however, vastly aggravated the flood danger and made them many times worse than if the slopes were covered with forest and soil wastage from cultivated fields were prevented.

While it is true that forests by themselves could not prevent floods in large rivers in times of exceptional meteorological conditions, it is similarly true that *without the forest* no engineering works on the middle or lower courses of the river can afford permanent and effective protection against floods.

Different opinions are being expressed by experts of high standing in their respective fields as to the best means of controlling floods. Some believe that the solution lies exclusively in the building of levees—straightening, deepening and widening of channels in the lower portions of the Mississippi. Some put their trust in spillways and in building large storage reservoirs, as exemplied by the storage dams built on the Miami River after the disastrous Dayton flood. There is also no lack of forest enthusiasts who claim that floods can be entirely prevented by maintaining a forest cover at the head waters. While there is merit in each of these methods no one of them by itself solves the problem, and all three, and run-off and to prevent erosion, with consequent formation of bars, narrowing the channels and silting up of reservoirs.

The value of engineering methods of control depends on how thoroughly the headwaters of the rivers are protected by forests. The forest, exerting an influence not over the greater portion of it, produces certain conditions which can never be entirely replaced by engineering methods. The dam, the reservoir, the settling bed, the levees and spillways influence only the reaches of the stream below them. The forest at headwaters influences the conditions of the entire river system. When the influence of these forests falls below a certain limit, engineering methods are futile; their efficiency rapidly fails and their very existence is threatened. The storage capacity of the reservoir and settling basin are destroyed by the sediment which is washed from the bare slopes; the bed of the canal is filled with it, harbors and rivers are constantly being choked by it in spite of the dredging. The accumulation of the detritus from the scourings of unprotected soils threatens the levees by the gradual raising of the river bed and requires their continual extension. As the floods at headwaters become higher with more erratic stream flow, the very dams which are built to restrain them are endangered.

Engineering methods alone cannot solve the flood problem — protection of the watersheds by forests is also necessary.

The problem of controlling our water resources is unquestionably one of the most important problems of internal development of the country. Streams throughout almost the entire country are becoming more irregular every year. In nearly every part of the country the use of water resources is becoming more and more intensive and the value of property, affected either by floods or irregularities of flow, has become so great as to make the control of streams of an increasingly greater importance every year. The Geological Survey estimated the damage from floods alone throughout the United States at some $95,000,000 on the average each year.

One of the greatest needs today is that the different activities essential for permanent improvement of rivers be brought into correlation and be conducted in accordance with a comprehensive plan. Each drainage basin should be treated as a unit from source to mouth and all practical methods of regulating and equalizing river flow throughout the year should be adopted. Forest protection at the source of streams, proper agricultural methods in the valleys and foothills which would increase the absorption of water in the soil and prevent erosion, construction of storage reservoirs for flood regulation where these are required, levees and bank protection where this work is needed, outlets and spillways, and all other work bearing on the control of water should be harmonized into one great unifying system for each drainage basin.

Is it necessary for this country to go periodically through terrible calamities, such as the southern states are now experiencing, in order to learn the simple lesson *that water, like fire, must be controlled at the start?*

Permanent improvement in flood prevention depends upon correlation of the necessary measures for it.

To attempt to hold together at the bottom an accumulated mass running wild from a hundred unfettered sources at the top is to emulate King Canute when he sat in his chair and ordered in his own great name the incoming ocean tides to recede.

While it would be ridiculous for a forester to claim that reforestation alone will prevent floods and bring about improvement in our rivers, it is every bit as ridiculous for the engineer to claim that levees and dredging by themselves can work permanent improvement in our rivers. The engineer and the forester must work hand in hand if our river system is to be converted from a source of danger and expense to one of high usefulness and revenue. This fact is so axiomatic that in Europe no system of river control would for a moment be contemplated that did not include protection of the watershed by forests or other vegetation. There can be no rational *water management* without *forest management.*

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HOLDING THE HEADWATERS IN LEASH

By WARD SHEPARD

Forest Inspector, United States Forest Service

THE MISSISSIPPI bears seaward in her floods a mighty derelict traffic gathered from far-flung mountains, plains, and farms. It is the traffic of wasted water and wasted soil. From millions of rivulets and creeks and small rivers it comes, each bearing its seemingly insignificant burden, each taken by itself a harmless thing. Yet these burdens, augmented by heavy rains and sudden thaws, converging from a thousand scattered sources, multiply their strength until the Mississippi becomes an unchained monster.

Great floods will always come, for man cannot hold back the storm-clouds nor keep their waters from rolling to the sea. But, within certain limits, he can restrain their violence. Levees, if high enough and strong enough, will hold floods to a fixed channel. Storage reservoirs will hold back part of the flood waters. Such works form the main attack on floods. But there is another attack—the natural storage of water—which is of great importance but which has never been adequately developed in this country, because for its greatest effectiveness it requires that vegetative cover, especially forests, be kept at the highest state of efficiency.

Floods, Forests, and Levees

Soil waste and water waste are at the heart of the flood problem. Yet their very immensity has obscured their importance. It is easy to see the swelling tide of a great flood, the desolation it leaves in its wake; but it is difficult to trace, even on a small scale, the widely scattered causes that contributed each in its way to the catastrophe. It is even more difficult to grasp the cumulative total effect of these causes at work over immense areas of land.

That vegetation—particularly forest cover—holds back and absorbs a great deal of water has been conclusively shown by careful scientific experiments both in Europe and in America. In Switzerland two small neighboring valleys—one forested, the other deforested—were studied for many years. Even after very heavy rainfall, the deforested stream carried from two to three times as much water as the forested stream. In California three forested valleys discharged into their streams only 37 per cent of the rainfall during the rainy season of January, February and March. They had absorbed the rest and were still paying it out slowly and in well-sustained streamflow after three months of dry weather. A neighboring deforested valley, on the other hand, quickly poured 95 per cent of its rainfall into the stream and went dry two months later. Other similar examples could be given.

Excessive erosion after deforestation is attested by innumerable striking examples from many parts of the world. Many navigable rivers have been so clogged with soil that navigation is no longer possible. Orange groves in California have been partially buried under tons of gravel and bowlders washed from fire-stripped mountain slopes. In one instance soil washed from a burned hillside of 200 acres completely buried a 12-acre alfalfa field. Such instances could be multiplied indefinitely.

Accurate scientific observations of this kind are much more easily made in small than in large valleys, where there is such a variation in soils, slopes, vegetation, and many other factors that it is difficult to weigh their relative effects on total streamflow and erosion.

Vegetation Controls Run-off

In spite of the large amount of scientific experiment and observation, especially in small valleys, on the value of vegetation for preventing rapid run-off and erosion, there is still doubt and debate over the meaning of the evidence. The mind finds it difficult to bridge the gap between the individual raindrop and the great flood in the valleys. Yet the greatest flood is merely the final sum total of the discharge of numberless tiny rills and rivulets, which in turn collect rain-water from the ground where it falls. This difficulty comes from failure to take into account the vast extent of land surface on which flood-causing rains fall and the equally vast surface over which vegetative cover may exert its influence. Only an insignificant fraction of the water in a great flood falls directly on the face of the river or flows from its immediate banks. The great bulk of it falls on thousands of square miles of land surface. Part of it seeps into the ground, to emerge months later as springs; some of it flows or trickles over the surface into little rivulets and so makes its way down toward the creeks and rivers. But whatever course it takes, most of it falls in places that afford a greater or less opportunity to cope with water while it is still in small quantities and moving at slow speed.

There are only two ways in which man can radically alter the condition of the earth's surface. One way is through tilling the soil. Poor tillage leads to rapid run-off and soil erosion; good tillage leads to absorption and stability of soil. The other great means of changing surface conditions is through the use or abuse of vegetative cover.

Leaving out of account the influence of growing farm crops, the importance of vegetation in controlling run-off and erosion in the Mississippi basin can be gauged by the enormous extent of grassland and forest within its confines. Grassland and forest can play their full part in water control only if they are kept vigorous and dense. But both our grasslands and forests have been depleted and their efficiency in water storage impaired over vast areas.

The forest is the best of all natural water-holders and soil-holders, but all forms of vegetation, including grass, have similar effects in varying degree. Forest cover baffles water in its efforts to reach the sea. The crowns of the trees intercept and evaporate a good deal of rain and snow, and forests use up large quantities of water in the process of growth. Much of the normal rainfall is absorbed by the thick, soft mat of fallen leaves, needles, twigs, cones, seeds, and decaying wood that covers the forest floor, sometimes to a depth of 3 feet. This mat, acting like a sponge or a wick, carries water down into the porous humus or vegetable mold and thence into the mineral soil. Here it joins the great body of underground water that may seep slowly for months before it emerges in some distant spring or rivulet.

Forests Hold Water

During a heavy storm, the absorptive capacity of the forest may be passed. Even so, the forest has already had a helpful effect in absorbing and retarding part of the water. By slowing down the run-off and by taking large quantities of water underground and delaying its passage to the streams, the forest tends to reduce flood heights and to prolong the flow of streams. Forest cover means, then, less fluctuation in the high and low water stages, slower run-off, and better navigation.

The forest exerts other powerful restraints on rapid run-off. Snow in the forest melts later and much more slowly than snow in the open, so that its burden is added to the streams after snow water from the open has already passed off. This may prolong high water but makes it less severe. Moreover, the forest is warmer in winter than open country, so that the soil may remain unfrozen or may freeze only slightly, and is thus able to absorb the water from melting snow. In the open, the soil is frozen hard and deep; and the snow, melted by the first warm rains, pours torrents into the streams.

The same things that make the forest a good water-holder make it a good soil-holder. And this soil-holding is extremely important not only in flood control but in the conservation of our soil wealth. Floods contain not only water but mud. The mud raises the flood crest, fills river channels, and cuts down their flood capacity, compelling the building of higher levees. It is a constant menace to such engineering works as storage reservoirs, which it fills up with silt.

A good, dense forest keeps the soil in place instead of loosing it into the rivers. Its fibrous roots bind the soil together. The thick mat of leaves and humus keeps the water from cutting into the soil. In a well-kept forest the streams usually run clear even after a heavy rain.

The destruction of the forest or other vegetation soon exposes the soil, which permits rain-water to run off quickly. The cutting power of water increases even faster than its speed; and the bare soil, no longer protected by leaf-litter, is rapidly washed into the streams. Millions of tons of our richest topsoils are yearly washed into the streams. They are irrecoverably lost to our farm and forest wealth and are adding enormously to the problems of navigation and flood control.

Forests vary considerably in their effects on run-off and erosion. They have most influence on steep slopes with impermeable soils; least in level country with porous soils. The processes here described apply to average conditions.

The forest, it is true, is only a shallow reservoir, so to speak, but it is vast in extent. This or that acre, this or that stretch of woodland, may seem to have only an insignificant effect on streamflow. But the cumulative effect of thousands of square miles of forest is an immense power for good that must be made use of.

Forests Must Be Built Up

It is not generally realized that we have immense areas of denuded and deteriorated forest land not needed or suited for farming. Something like 275 million acres of once forested lands are now in farms, but about 225 million additional acres of forest land have been logged off and not taken for farming. Many of these forests have been denuded or depleted by destructive lumbering and fire. Many of them have been turned into worthless barrens. Most of them are swept by recurrent fires, the vegetation is thinned out, the leaf litter and humus destroyed, and the bare soil exposed to gullying and washing. In the denuded forest, neglected and repeatedly burned, the vegetation finds a scant hold on the sterile soil and is often reduced to a scraggly, open growth of brush and weeds. The soil, gouged and exposed by logging and fire, is no longer protected by a thick mat of litter. Such forests cannot compare as water-holders or soil-holders with a well-kept dense forest with a thick litter and tangled undergrowth.

Most of our forests are only partly fulfilling their functions of soil-holding and water-holding. They must be built up and restored to their full density; the destroyed humus must be replaced by a new accumulation; the forest must everywhere be kept green, thrifty, and well managed. Such forests can be built up only by universal protection against fire and destructive lumbering.

The most critically important forests of the Mississippi basin are those of the western slopes and foothills of the Appalachians. The Ohio and Tennessee Rivers, which have their sources in these mountains from southern New York to Georgia, collect and pour into the Mississippi something like one-fourth of its total waterflow. Their headwaters drain rugged slopes subject to violent downpours and destructive erosion. Under the attrition of the ages, these ancient mountains had reached a state of equilibrium in which natural erosion was largely checked by the dense cover of virgin forest. Man has disturbed this balance. With fire and ax he had made enormous inroads into the original forest. Destructive logging and fire have long held sway in the Appalachian Mountains. Precious soil that has been tens of thousands of years in building up from weathered rock and decayed leaf-fall has taken its way toward the sea.

The Ozark Mountains, occupying a large stretch of country between the Arkansas and Missouri Rivers, likewise occupy a strategic position. Their forests have been badly depleted by lumbering, fire, and the clearing of slopes for agriculture.

The forests of the eastern slopes of the Rocky Mountains, whence flow such important tributaries as the Missouri and the Arkansas, fortunately have far better prospects than the Appalachian forests; for many of them are embraced within the National Forests, which are managed not only for timber production but for stream protection.

Systems of Flood Control

In the Lake States, forests have a less decisive effect on streamflow and erosion than other forests of the Mississippi basin because of the gentle topography and because of the porous sand and gravel soils, which readily absorb water. The swamp forests, however, are extremely important in their ability to store flood waters. Nowhere in the country have forest depletion and denudation been so extensive as in the Lake States.

Throughout the central farming regions, stretching from southern Wisconsin and Minnesota down to the southern pineries, there is in the aggregate an immense acreage of woodland, much of it in farms. Many of these woodlands are injured by fire, overgrazing, and overcutting. Large areas of broken, sloping land have been cleared and are subject to heavy run-off and erosion. Though less important than the mountain forests, they are by no means a negligible factor in erosion and run-off.

No system of flood control that leaves out of account these vast and strategically situated forests can ever wholly succeed. Levees will always be the primary means of controlling the lower Mississippi. But green, vigorous, timber-producing forests must become the primary means of holding the headwaters in leash.

The benefits of forest cover in controlling streamflow and reducing erosion have been abundantly demonstrated in many countries.

REFORESTATION—A PRACTICAL MEASURE OF FLOOD CONTROL

REGNAULT, in his book on "Deforestation and Decadence," paints a vivid picture of the effects of deforestation.

> "When the mountains are deforested all is ruined. The rains . . . fall in torrents and rush off the denuded soil. They first carry off the vegetable cover. The mountain shows its rocky skeleton, the rocks break up, cones of erosion are formed, landslides, gullies, unstable slopes become so many running sores by which the substance of the mountain is carried down. The rocks offer more or less resistance according to their texture, but none withstand. Even granite splits up into enormous blocks which roll irresistibly down the valleys. . . . When the highlands are ruined, what becomes of the plain? . . . The river becomes a torrent when it rains, carrying down earth, trees, and rocks. Swollen beyond measure, it flows over the plain in a sudden flood which destroys houses, flocks, villages, and people. . . . The sudden flood is characteristic of denuded countries . . . the mountain can no longer supply the valley with water. Now is the time of drought and famine."

France

France, through bitter experience, has learned the lesson of deforestation of mountains. Other countries, such as Palestine, Assyria, Arabia, Greece, Tunisia, Algeria, Italy, Spain, Persia, Siberia, Dalmatia, all bear the same evidence of deforestation. In 1860, France, after terrible floods of 1856 that ravaged the valleys of the Rhine, the Loire, the Rhône, the Garrône, and the Seine and caused the loss of a great number of lives and did damage amounting to more than $38,600,000, passed the first law on the reforestation of the mountains. Since then and up to about 1913, some 500,000 acres have been acquired and more than one-half of the land has been planted. Already 163 of the mountain streams have been entirely controlled and 654 are beginning to show the controlling effects of the forests upon their watersheds. Thirty-one of the mountain streams now entirely controlled were considered hopelessly bad half a century ago. Two principles underlie the control of erosion in the mountains, first, to stop the earth from moving as a whole, and, second, to cover it with shrubs and forests. A remarkable example of the control of a mountain stream, which did a great deal of damage from 1832 to 1847, is found in La Grollaz. The reforestation work was started in 1880. Today, the stream is a pretty brook with waterfalls over artificially constructed cement dams, protected by a dense cover of alder, which holds the soil immediately along the brook. Further up from the stream, pine has been planted with the result that this mountain stream today looks pretty much like a New England trout stream, bordered by trees 50 feet in height. It is expected that $50,000,000 will be spent before the work of reforesting the mountain slopes for protection is completed.

* * *

Switzerland

Three-fourths of the forests of Switzerland are regarded at the present time as protection forests; that is, they are located in the basins of torrents, where they serve to lessen the harmful effects of run-off, or they afford protection against avalanches or against severe climatic conditions. Since the maintenance of such forests is conceded to be essential to the general welfare, federal laws have been in force since 1876 which forbid cutting except with the consent of the forest administration, and as a rule clean felling is forbidden altogether. The effect of these provisions has been very satisfactory, the area of protection forests has been maintained and increased, and the people have in general been well disposed toward the matter; so much so that in 1897 a popular vote extended the application of the idea of "protection forests" to include not only the Alps, but also the Jura and some portions of the plateau region.

* * *

Austria

In Austria, before the war, a law for reforesting mountain slopes based on that of France was passed in 1884 to control mountain streams. This law carried an annual appropriation of $100,000. For the regulation of the lower portions of the rivers, $1,350,000 was appropriated at the same time, and of this sum $400,000 has been expended on reforestation.

* * *

Russia

In Russia, before the war, over 100,000,000 acres of forests have been classed as protection forests, or forests which are indispensable to control of stream flow.

Japan

Japan has close to 2,000,000 acres of forests specifically designated to prevent denudation of soil and occurrence of floods, embracing some 353,000 separate forest areas.

* * *

Italy

The disastrous effects of deforestation of the mountains in Italy—a country of mountains—are particularly striking. Small streams in the Alps, the Apennines, the Abruzzi mountains and also the mountains of Sicily and Sardinia, swelled by rain and the thawing of snow into turbulent torrents and no longer restrained by forest vegetation, rush down with tremendous force and cover agricultural land with sand and stones, causing the owner enormous and very often irreparable loss. In 1877, the first law for maintaining protection forests was passed. It was not, however, until the passage of a new law in 1910 that made obligatory upon communities and private owners reforestation of denuded areas in the mountains that rapid progress was made. To carry out the provisions of the 1910 law, the government appropriated for the first five years about $8,000,000. A large part of this expenditure is for the purchase by the government of forests in the mountains, as well as of areas in need of reforestation.

* * *

Spain

In Spain in 1908 a law was passed for the conservation of forests situated in flood areas and in other places where the permanence of the forest is essential as a preventive against erosion and rapid surface run-off.

Can the United States learn nothing from these painful experiences of the older countries?

FOREST AND STREAM FLOW

By JOSEPH S. ILLICK, *State Forester of Pennsylvania,*
and E. F. BROUSE

A SERIOUS drought was general throughout Pennsylvania during the late summer and fall of 1922. It prompted the Department of Forestry to make a survey of the situation to determine practical and effective measures for future relief work. The result of the investigation, as stated in the following paragraphs, indicates the value of the forest in preserving water and in affecting stream flow.

These facts are worthy of consideration by any student of methods tc prevent floods.

An official of a water company stated that during previous droughts ol the last twenty-five years there was at least three times as much water ir the reservoirs as during the drought of 1922. All the factors influencin water production appear to be similar to those of former years except that a more incomplete and inferior forest growth now covers the watersheds

Forests Conserve Springs

Lumbering operations have cut off all the large timber and forest fires have repeatedly burned over the hill sides and consumed what the lumbermen left and mos of the young growth that followed the lumbering operations.

Twenty years ago a total of 250,000 gallons of wate flowed from a spring near Ashland. During the drought 50,000 gallons flowe from it, that is, only one-fifth as much as twenty years ago. Twenty year ago, when considerable timber was left, there were seventeen springs feedin the reservoir. Now only seven of these springs are flowing and severa of these are very low. During these two decades all the timber has bee cut, and forest fires have repeatedly burned over the land. A spring know by many inhabitants not to have been dry in the last thirty-seven year stopped during the drought of 1922. It is the belief of those who kno the region best that this is the first time that it ever ceased flowing.

Figures show that the water level in the largest industrial reservoi (Queenahoning Dam of Cambria Steel Co.) in the state was very low i 1922. The drainage basin covers an area of 59,000 acres. About five eighths of the drainage basin consists of farm and waste land. The fore growth on the remaining three-eighths is rather complete and satisfactor The average age of the forest trees, which are chiefly hardwoods, is thirt years. The normal intake of the reservoir is seventeen times greater than the intake during the 1922 drought.

Of nine large water companies in the anthracite coal region, three had no reserve supply for household use or fire protection during the drought of 1922, three had a very small reserve supply, and three had an almost normal supply. It is a significant fact that the last three had drainage basins that were well covered with a forest growth, while the watersheds of the other six were covered with a poor and broken forest growth that had been repeatedly burned over by forest fires.

In all instances where the water became extremely low, it was unfit for human consumption without being boiled, and did enormous damage to industrial plants because of its high acid content. The people and industries were not the only sufferers from the poor quality of the water, for fish and other animal life also suffered greatly. The smaller creeks and rivers were contaminated to such an extent that fish were killed by the thousands.

The actual cost of the drought is very hard to estimate. Few industries operating in the regions where the drought was most severe escaped from its evil effects. Coal production was reduced in both the anthracite and bituminous regions. Water had to be hauled in tank cars for many collieries. This was the only way to avoid a shutdown. In some regions it was also necessary to haul water for the operation of railroad engines.

Forests Affect Drainage

The municipal water company of Altoona, in addition to its own consumption of 4,250,000 gallons, supplied daily 3,500,000 gallons to a railroad company and 500,000 gallons to another water company. This consumption is nearly twice greater than normal. On January 1, 1923, there was a four-month supply on hand at the present rate of intake and output. The drainage basin extends over an area of about 5,000 acres and is covered by a good forest growth, consisting chiefly of mixed hardwoods, and conifers having an average of about thirty years. This basin has not been burned over in recent years, and shows clearly and convincingly that a good forest cover on a watershed is of great value.

The Girard Water Company of Pottsville has done much forest preservation, forest fire prevention and forest tree planting work on their drainage basins. It was in a position during the drought of 1922 to supply water to many industries of the Anthracite Region. Seventeen collieries, in addition to many regular consumers, were able to operate solely because of the water supply obtained from this company. While their storage capacity is no greater than that of some other water companies, they had the supply available because their watersheds are heavily forested and well protected. A good water run-off was in evidence at all times.

It is conceded that reforestation saved the city of York from shortage during the drought of 1922. Mr. Edgar Kable, Superintendent of the York Water Company, writes that: "By reason of reforestation it has been estimated that the flow of springs has increased approximately 50 per cent, and undoubtedly tided over the dry weather season; whereas without this development there might have been considerable and undoubtedly a restricted use of the public water supply."

Drought and Forest Cover

The drought was very severe in the coal regions, both the anthracite and the bituminous, where forest devastation is more extensive and more complete than in any other major regions of the state. In both of the coal regions forest fires are more numerous and more severe than in any part of the state. During 1922 the area burned per fire in the coal region was 1.2 times greater than in the remainder of the state. For every forest fire that occurred on the 13,024,399 acres of forest land in the state one fire occurred on 2,494,172 acres of forest land in the coal region. The average population per square mile in the coal region is 277, while the average for the state is 194. This would account for an increased demand for water which is offset to some extent by the fact that a proportionately larger area of land surface in the coal regions is devoted to watersheds than in other sections of the state.

That the drought was most severe in the coal regions cannot be attributed to a smaller rainfall, for figures show that the precipitation was lower in many places outside of the coal regions. The causes given generally for the water shortage are the extreme light rainfall and inadequate storage capacity of reservoirs. Both unquestionably affect the amount of water available, but water for human consumption and industrial uses should be stored or reserved in a different way than merely holding it in dams that blockade streams and brooks. The entire basin should be covered with a forest growth that will make it a retaining reservoir. This is the ideal way to build up a reserve water supply, and will be effective during the periods of severe drought.

◆

USE COMMON SENSE

By Col. W. B. GREELEY

Chief of the U. S. Forest Service

THE Mississippi basin contains about 89,000,000 acres of forested or denuded land which has little or no utility except in growing timber. No one can assert that the condition of this vast land surface, or the degree of care or of neglect it receives, has no bearing upon the flow of the Mississippi River.

Any benefits derived from reforestation cannot be secured overnight. They will come about only through a long space of time. Hence forests cannot be substituted for the engineering structures upon which our main reliance must be placed for controlling heavy flood discharges. They can supplement dams or levees but cannot take their place.

The mat of litter found under thrifty, unburned forests acts like a sponge, and the water-absorbing capacity of the soil itself is greatly increased by the constant accretions of decaying humus.

Every forest fire in the Mississippi basin tends, sooner or later, to augment flood conditions. Every abandoned or neglected piece of poor hillside farm land has the same tendency. Destructive lumbering and overgrazing, which leave naked soil behind them, are sure to contribute, at one time or another, to some flood crest.

Behind and supplementing the levees or other structures that must be built, we get back to the land. And we should not fail to restore, as far as it may be done, the natural storage and protection from erosion that may be derived from common sense and practical wisdom in our everyday use of land.

STOP SOIL WASTAGE

By H. H. BENNETT

United States Bureau of Soils

FAILURE to hold the absorptive surface soil of fields and pastures against the denudation of erosion has contributed to a much more rapid removal of the water that falls upon these eroded lands. The mellow topsoil that is gone was far more retentive of moisture than the comparatively impervious subsoil that sheet erosion has left behind.

Failure to build terraces on sloping fields generally and to plant grass and trees on the steeper lands highly susceptible to rain wash, accounts for much of the excess of water now sweeping down the Mississippi. If this kind of soil wastage on an enormous scale is not stopped, there is little likelihood that floods will be controlled. Practically nothing is being done about this phase of flood prevention. There are no hillside terraces north of the Arkansas River. Eighteen inches of topsoil has been removed from the youthful fields in some parts of northeastern Kansas. The entire topsoil is gone from hundreds of thousands of acres in western Virginia, western Pennsylvania, eastern Kentucky and southeastern Ohio. From these lands rainwater courses much faster to the Mississippi than formerly. Terraces and grass woodlots, forests, and other soil-binding and soil-building crops will vastly improve the flood situation; not only will they slow up the run-off of water, but they will save the most valuable part of the soil and will reduce the clogging of streams which cuts down their carrying capacity, and adds to the flood danger.

FLOOD CONTROL

By WALTER PARKER

Economist, in the "Manufacturers Record"

THE problem as a whole is interrelated. Dry lands need more water; low lands need protection from too much water. Upland farms need the soil which annually washes away from them.

The whole country needs new forests. Great reserves are needed for the preservation of wild life. Everywhere something needs to be done, and the whole is intimately related to the problem of flood control.

Those engineers who are willing to discuss the matter at all must first state the problem to be solved. The lowland engineer sees only a great flood, already formed in all its might, and so plans strong levees or levees and spillways.

The upland engineer sees water going to waste, and so plans irrigation and power-development works. The forestry people concentrate their thought on the replanting of denuded areas. Soil experts talk about putting a stop to erosion. All of these things are wholesome, desirable and closely related.

But there is no one, no bureau, department or commission in all the government service empowered to bring them all into proper juxtaposition, to plan comprehensively, to tell the engineers what they are to do, any more than there is any machinery within the Federal Government empowered to coordinate the work of the many bureaus which have to do with many now isolated but closely related angles of one big problem. Basically, it is simply a matter of national policy and national economics.

SOME LEADING EDITORIALS

TREES AND FLOODS

"Reforestation of the Mississippi basin is well worth while for its own sake, even though it should result in preventing no drop of water from flowing downstream to the danger line. The effects of the appalling waste of our native timber is each year felt more and more sharply in growing scarcity and in rising prices. If we are to maintain a native timber supply, there is only one way to do it, and that is by intelligent reforestation on a large scale and for the long pull. Perhaps the only beneficent effect traceable to the recent floods is the nation-wide publicity they have given to the need for extensive reforestation in most of the thirty states drained by the Mississippi River. It is to be hoped that each of them will give the matter thoughtful consideration and take such action as will best serve both ends—the better retention of local rainfall and the upbuilding of a more adequate timber supply."—*Reprinted by special permission of the Saturday Evening Post, copyright, 1927, by the Curtis Publishing Company.*

MORE TREES—FEWER FLOODS

BUFFALO TIMES: Charles Lathrop Pack, president of the American Tree Association, is right. Fundamentally the argument he advances is a familiar one—the relationship between forests and rainfall is well known. But the reasoning in the premises has not always been stated so consecutively and clearly as he has stated it. He has done a substantial service in setting forth this matter so tersely and plainly that "he who runs may read," and he who reads can hardly fail to remember.

TREES AND FLOODS

WASHINGTON TIMES: Forests are necessary at the headwaters of streams. The trees break the force of the raindrops, and the forest floor, acting as a large sponge, absorbs rainfall and prevents run-off and floods. Unless there are forests at the sources of streams and rivers, floods occur. The spring uprisings of the Mississippi, Ohio and Missouri Rivers are due largely to the lack of forests at their headwaters. In the regions drained by these streams the run-off water is not absorbed as it should be.

FLOODS AND THE FORESTS

Philadelphia Bulletin: The forests of the country are great reservoirs that hold back rainfall, and let it down to the rivers gradually, instead of running off in floods. The five great forest districts of the United States cover approximately thirty-six per cent of the total land surface. Lumbermen have taken tremendous toll in Michigan, Wisconsin, Minnesota, and the long leaf southern pine region. Fire has worked havoc. In the semi-arid Rocky Mountain forest territory, fire, overgrazing and overcutting have removed and hampered forests, where they grow less rapidly owing to aridity. It is the part of national foresight to regulate and remedy these conditions. Headwater reservoirs and tree planting should go well together. A national policy to deal with the Mississippi will comprise both.

A VIVID LESSON

Winston-Salem Journal: Whether with malice aforethought or by providential accident, the Mississippi flood comes most appropriately to teach America the inexorable penalty of ruthless deforestation and to suggest more eloquently than words that we must start a systematic reforestation along the headwaters of our great rivers.

A LESSON FOR "FOREST WEEK"

Peoria Journal: There is not the slightest doubt that forests absorb a vast amount of rainfall which otherwise would develop floods. The construction of levee districts also diminishes areas of absorption. It is quite possible that President Pack exaggerates the importance of deforestation in its effects upon floods which were not uncommon in the days when forests were virgin. At the same time, trees are national assets of great value. To assume the contrary is the height of folly.

We are rapidly reaching the point where the exploitation of natural resources is becoming a matter of universal concern.

"AFTER US, THE DELUGE"

Atlanta Journal: If that knowingest of teachers, Dame Nature, wer asked the cause of the Mississippi flood she would go back for answer t forgotten years when men were recklessly cutting away forests from th headwaters of the royal river's tributaries. She would show how vast vo umes of rain which she intended to be soaked in by her spongy woodland were left to surge down hillsides, cutting gulches as they went, into streams which broke from their banks with the excessive inpour. She would trace this ominous process along a thousand swelling creeks, along a hundred chafing rivers, on to the Missouri, the Ohio, the Tennessee, the Arkansas, on to the deluge of disaster. And, being given to driving her lesson inexorably home, she would add that after comes drought, because the water which the forests would have served to store up in the earth for gradual distribution has been spent, as it were, in riotous living.

MOVING FOR FLOOD PREVENTION

CHRISTIAN SCIENCE MONITOR: In the opinion of Charles Lathrop Pack, president of the American Tree Association, the people of the United States have, in the present flood situation along the Mississippi River and its tributaries, an opportunity to learn a lesson which should have been learned long ago. The disaster which has resulted from somewhat unusual conditions this spring only emphasizes, he declares, the lack of foresight which causes millions of dollars in losses every year as a result of erosion due to the destruction of forests which formerly impeded the rush of surplus waters in the vast areas which feed the Mississippi and the lesser rivers which join it in its course. Mr. Pack says it is imperative that forests be reproduced at the headwaters of streams in the great area constituting the basin drained by the Mississippi, the Ohio, and the Missouri Rivers.

THE LESSON OF THE FLOOD

BROOKLYN CITIZEN: It has been considered the height of folly to "lock the stable door after the horse has been stolen," but if more horses are to be kept in the same stable it is the part of wisdom to provide a lock, even though it may be impossible to get back the stolen animal.

Experts are now urging that trees be planted around the headwaters of the Mississippi River. To those who may protest that such action is too late to have any effect upon the disastrous flood, and that it is useless to lament because reforestation was not put in force years ago, it may be replied that there will be other floods, some, perhaps, just as disastrous or even more awful than the present one if something is not done to prevent.

It is to be hoped that President Coolidge will heed the call of these advocates of conservation and reforestation, and that Congress and the public may both be enlisted in the practical effort to prevent or minimize future floods.

THE MISSISSIPPI PROBLEM

Washington Post: The commission must reckon with the growth of conviction of well-informed engineers that it would be wiser to permit the Mississippi in its periods of flood to roam untrammeled over lands not worth protecting. The river is a series of basins into which excess water naturally flows. Converted into forest land, from three to five million acres in these basins would net a far higher return in timber than is now possible in crops, and would serve at the same time as a relief area. This is not a plea for reforestation as a means of flood control, but an argument for enabling some land subject to flood to pay for itself. Louisiana recognizes the advantages of such a policy by relieving timberland from the payment of taxes.

AN OBJECT LESSON

Pittsburgh Gazette Times: Never before has the country had in Forest Week such a striking object lesson in support of the principles and objects of the American Tree Association as is afforded by the Mississippi flood. The advocates of forest conservation and of reforestation, under the leadership of the Federal Government, are confident that unless reforestation at the headwaters of the central valleys is immediately undertaken and prosecuted vigorously a Mississippi flood in the not remote future will be far more calamitous than that of this spring. But flood prevention is not the sole benefit to be gained from forest preservation and reforestation.

FORESTS AND FLOODS

St. Paul News: Whatever else may be said of it, the Mississippi has certainly dramatized forestry week.

There is a definite connection between its sudden rise and the disappearance of trees and thousands of square miles of territory along its banks and tributaries.

Where their watersheds are covered with forests, rivers rise slowly because it takes the rain a long time to seep through the moss and leaf mold. Where watersheds are barren of forests, the rain runs down over them as it does over a roof.

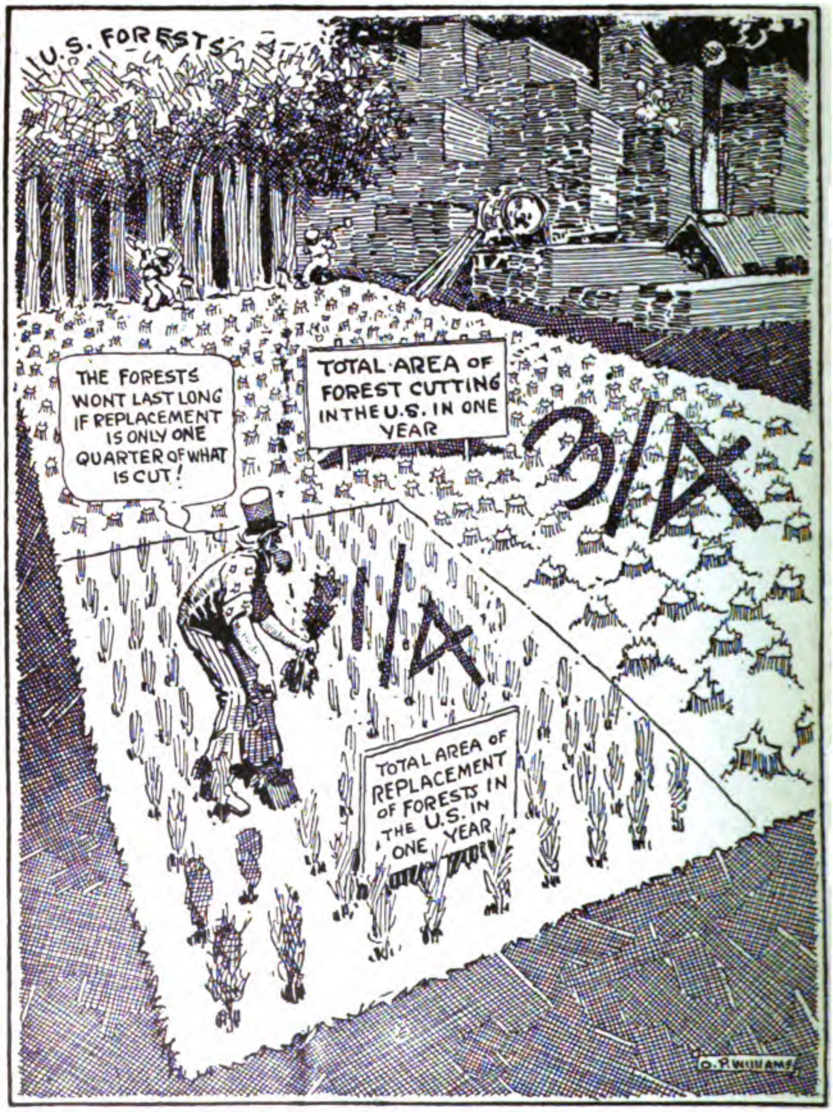
Forests not only prevent floods, but they hold rainwater in storage for dry seasons.

There is more benefit in the preservation of forests than arises from the supply of timber and pulpwood it insures.

SOME FLOOD FIGURES

Number of Homes Flooded	700,000
Number of People Destitute	600,000
Towns Flooded	1,000
Farm and Plantation Area Flooded	15,000 square miles
Number of Farms under Water	Hundreds of thousands
Acres Planted after First Flood	1,100,000
Acres Swept Away by Second Flood	280,000
Losses	$200,000,000 to $400,000,000
Losses to Railroads	$15,000,000
Relief Funds Used by Red Cross	$16,000,000
Relief Funds Used by the Government	$7,000,000

INCREASE THE PLANTING


U.S. FORESTS
THE FORESTS WONT LAST LONG IF REPLACEMENT IS ONLY ONE QUARTER OF WHAT IS CUT!
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TOTAL AREA OF REPLACEMENT OF FORESTS IN THE U.S. IN ONE YEAR
O. P. WILLIAMS

O. P. Williams in the Washington, D. C., Herald

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FORESTS AND WATER IN THE LIGHT OF SCIENTIFIC INVESTIGATION

BY

RAPHAEL ZON
Director, Lake States Forest Experiment Station
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FORESTS AND WATER IN THE LIGHT OF SCIENTIFIC INVESTIGATION

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Object of the Report

Of all the direct influences of the forest the influence upon the supply of water in streams and upon the regularity of their flow is the most important in human economy. Yet so many are the factors which play related parts in this influence, so great is the difficulty of observing them with precision, and so wide the range of economic interests affected, that considerable divergence of opinion has arisen on the subject. This, however, if prompted by a sincere desire to reach the bottom of a complicated and vital problem, can only be productive of results of the highest scientific value.

There is, perhaps no other problem facing the American people to-day which demands such care in the scientific accuracy of its data and conclusions as does the relation between forests and water. It is imperative, therefore, that no final conclusions be drawn in regard to this relation until ample, reliable, and critically revised evidence upon which to base them is available. A national policy which, though considering the direct value of forests as a source of timber, fails to take full account also of their influence upon erosion, the flow of streams, and climate, may easily endanger the well-being of the whole people.

This paper aims to bring together impartially all the well-established scientific facts in regard to the relation of forests to water supply. Such a critical statement of our present knowledge of this subject should be helpful in separating what is definitely known of this relation from that which still needs to be determined.

Methods of Determining the Influence of Forests Upon Stream Flow

The influence of the forest on stream flow can be determined in two ways: (1) By actual measurements, continued for sufficient time, of the total discharge and of the high and low stages of rivers having drainage areas essentially similar in regard to precipitation, geologic formation, topography, and soil, but differing in the amount of forest cover, and (2) by determining, through the measurement of individual factors, the total amount of water available for stream flow.

The first method, since it deals directly with the measurement of water, may properly be called the hydrometric method; while the other, which deals chiefly with the physical and mechanical effects of the forest upon evaporation, run-off, etc., may be termed the physical method. The first method studies the final result of all the factors affecting stream flow as they are shown in the behavior of the stream. It is the most direct, and would be the most practical, provided all the conditions of the watersheds studied, except forest cover, were essentially similar. Since, however, such similarity between wastersheds is seldom met with in nature, this method, which has frequently been employed by engineers, is particularly liable to error. Further, the existing hydrometrical data are incomplete, for the hydrographic method requires the nicest observations, extending over a considerable period of time. The defects of the method in this regard were well brought out at the International Milan Congress of Hyrographic Engineers of 1905, as shown in the summary of the papers presented there.

The ideal application of this method would consist in comparing the regimen of a stream flowing from a completely forested watershed with the regimen of the same stream after its forest cover has been removed. As a control area there ought to be another watershed, exactly similar in character, on which the forest cover remains unchanged while that on the one under experiment is being removed. To make such a comparison thorough and accurate the topography, geological formation, and character of the soil of the two watersheds should be surveyed, and each watershed then equipped, at different elevations, with ordinary and self-registering rain gauges, as well as with instruments for measuring evaporation, wind velocity, level of ground water, and especially the flow of the stream during different seasons of the year. This would yield reliable information as to the influence of forest upon stream flow for regions having similar soil, climate, and character of forest. Such experiments, however, with the exception of one now being conducted at Emmenthal, Switzerland, by the Swiss experiment station, and one at Wagon Wheel Gap, Colo., by the Forest Service, in cooperation with the Weather Bureau, have never been made in any part of the world. The most common practice, especially with engineers, has been to compare the run-off from drainage areas in the same general region, of which one may have more forest cover than the other. If the comparisons were based on equally large numbers of stream gaugings and dependable meterological records, and the drainage areas compared were similar in regard to topography and soil, the average results might assume some practical value. Unfortunately, however, reliable gaugings for a given stream too often can not be supplemented by reliable meterological data for the same region. Therefore, while there is no end to the material gathered in this way, it is often contradictory at best showing only tendencies, and failing to determine with any accuracy the nature and extent of the influence which the forest has upon stream flow.

The second method analyzes separately the influence of the forest upon each of the different factors affecting stream flow, and the final effect of the forest upon stream flow is deduced from the combined effect on all the factors. While less direct, this method lends itself more readily to experimentation, and has been largely employed by foresters.

Since a large amount of reliable data concerning the influence of the forest upon the amount of precipitation over forested and unforested drainage areas upon evaporation, surface run-off, percolation, etc., have been obtained by this method, it will be discussed first.

PART I.—RESULTS BY THE PHYSICAL METHOD

FORESTS AND CLIMATE

The influence of forests upon climate has been a subject of investigation for a long time, and is not settled yet. Now and then this influence has been exaggerated, thus leading to the other extreme of denying it entirely. In discussing the subject, therefore, one has to be very careful in selecting facts and in drawing conclusions from them.

The physical and physiological processes which accompany any plant growth must necessarily reduce the temperature of the air, at least during the vegetative period. First, because the leaves evaporate water. Second, because the heat of the sun is consumed in this evaporation, and the plant can not become heated to the same extent as, for instance, a rock or soil without any vegetative cover. Similarly, the ground under plants can not become greatly heated on account of shading. Third, the surface from which heat radiates at night is much greater when vegetation is on the ground than when the ground is bare. The cooling effect on the air by crops has been experimentally proven. For every pound of dry substance produced it has been found that corn evaporates 233 pounds of water and turnips 910 pounds.

Under good cultivation an acre may produce about 7 tons of dry substance. If the evaporation of water be only five hundred times more than the amount of dry substance produced, then an acre will evaporate during the vegetative period about 3,500 tons of water. This example shows the extent to which ordinary crops can contribute to the moisture content of the air and the cooling which accompanies this evaporation. Forests, being the most highly developed form of vegetable life, exert this influence in the greatest degree.

The first systematic observations upon the effect of forests on climate were made in Bavaria. The climatic influences first observed were those which are least changeable from year to year and which are fairly uniform over large areas, namely, the temperature and humidity of the air, evaporation, temperature of the soil, and percolation of the water into the ground.

TEMPERATURE OF THE AIR

Table 1 gives the results of early observations upon the temperature of the air outside and inside the forest carried on in central Italy,[1] eastern France,[1] in the mountains of Alsace, Bavaria,[2] and eastern Prussia.[3] The stations inside and outside the forest were scarcely a mile apart. The differences between the temperature of the air outside and inside the forest are shown by plus and minus. Plus indicates that the temperature in the forest is higher; minus, lower than in the field.

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[1] Woeikov, A. I. The climates of the world (in Russian). St. Petersburg, 1884.

[2] Ebermayer, E. Die physikalischen Einwirkung des Waldes auf Luft und Boden. Berlin, 1873.

[3] Muttrich, A. Jahresbericht uber due Beobacht ungsergebnisse der im Konigreich Preussen und in den Reichslanden eingerichteten forstlich-meteorologischen Stationen, 1875, 1876.

TABLE 1.—*Temperature of air in the forest compared with that in the open*

	Central Italy	Eastern France	Mountains of Alsace	Bavaria	Eastern Prussia
February-April:	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
Average of daily maximum		−1.44	−1.98	−0.90	−1.26
Average of daily minimum		+1.44	+3.42	+.36	+.18
Mean temperature			+.72	−.54	−.54
May-July:					
Average of daily maximum	−7.88	−5.76	−4.50	−3.96	−2.52
Average of daily minimum	+2.88	+2.16	+3.42	+1.98	+.90
Mean temperature	−2.16	−1.8	−.54	−1.62	−.72
August-October:					
Average of daily maximum	−6.48	−4.68	−3.42	−5.76	−2.88
Average of daily minimum	+1.98	+2.34	+4.32	+2.88	+.36
Mean temperature	−2.34	−1.08	−.36	−1.44	−1.26
November-January:					
Average of daily maximum		−1.62	+1.62		−.54
Average of daily minimun		+1.08	+3.06	+2.16	−.36
Mean temperature		−.18	+2.34	+1.08	−.36
Entire year:					
Average of daily maximum		−3.42	−2.26	−2.70	−1.8
Average of daily minimum		+1.8	+3.6	+1.8	+.36
Mean temperature		−.72	+.72	−.54	−.72

This table brings out clearly the moderating influence of the forest upon temperature of the air. In the forest the maximum temperature is always lower, and the minimum temperature higher, than outside. More recent observations extending over long periods in France, Germany, Austria, Switzerland, and other countries have confirmed the earlier results.

The yearly mean temperature at equal elevations and in the same locality has invariably been found to be less inside than outside a forest. In a level country this difference is about 0.9° F. It increases, however, with altitude, and at an elevation of about 3,000 feet is 1.8° F.

The monthly mean temperature is less in the forest than in the open for each month of the year, but the difference is greatest during the summer months, when it may reach 3.6° F., while in winter it does not often exceed 0.1° F.

The daily mean temperature shows the same difference, but to a greater degree. During the hottest days the air inside the forest was more than 5° F. cooler than that outside, while for the coldest days of the year the difference was only 1.8° F.

The temperature of the air within the forest is, therefore, not only lower, but also subject to less fluctuation than in the open.

It is in tropical and subtropical regions that the influence of the forest upon the temperature of the air is probably greatest. In northern British India, in latitude 24°–27° N., the mean annual temperature for the year varies but little with latitude. In winter the rainfall is very scant, and in summer very abundant. Before the rainy season the valleys of northern India have a period of extreme hot weather and drought. On the whole, the temperature and the dryness are moderated by proximity to the sea.

The country along the Ganges, and in general to the west of the lower extension of Brahmaputra, is almost treeless, while in Assam, along the middle extension of Brahmaputra, there are large forests. A comparison of temperatures at these places, made by Woeikov,[4] and given in Table 2, shows clearly the influence of the forest upon the temperature and humidity of the air. Of the places named, Brahmaputra lies at 24° N., the others between 25° and 27° N. The arrangement is from west to east.

TABLE 2.—*Difference in temperature and humidity between treeless and forested regions, British India*

Locality	Distance from sea	Mean temperature				Absolute maximum temperature	Relative humidity (per cent)			
		April	May	June	July		April	May	June	July
Treeless region:	*Miles*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*				
Lucknow	526	86.18	91.94	91.58	86.72	114.44	30	36	54	74
Benares	367	86.36	91.76	91.04	85.46	113.00	41	60	81	82
Patna	267	86.54	88.52	88.52	84.56	112.28	----	----	----	----
Berhampur	168	84.28	86.18	84.56	83.66	111.38	52	60	75	79
Forested region:										
Goalpara	265	77.36	78.62	80.42	81.86	95.18	66	77	85	84
Sibsagar	345	74.30	77.54	82.76	83.30	96.08	81	82	83	83

The figures in the table indicate that forests play a much greater part in moderating the temperature in the hot and dry months of April and May than does proximity to the sea. The same thing holds for the relative humidity, especially in Sibsagar, which is the center of the forested region. The most striking influence of the forest is the lowering of the absolute temperature maxima. Proximity to the sea has but little effect upon this, but as soon as the forest region is reached, the absolute maximum temperature is at once decreased by about 15° F. Especially striking is the difference in the average temperature in May between Benares and Goalpara. The distance between the two places is only 462 miles, the latitude about the same, and the intervening country level. Both are at considerable distances from the sea, yet the difference in the average temperatures for May is 13° F., or about 1° for every 35 miles. This difference in temperature Woeikov explains by the presence of forest in Goalpara.

Woeikov further cites observations in the basin of the Amazon River, which possesses the largest forest area in the world. The middle and upper extensions of the Amazon River are about 621 miles from the Atlantic Ocean and are separated from the Pacific Ocean by very high mountains. At such great distances from the ocean, and so close to the equator, one would naturally expect to find very high temperatures and great dryness. Yet there the average temperature of the warmest month and the absolute temperature maxima are not greater than at the sea, and even not as high as the temperatures often experienced in middle latitudes. This is shown in Table 3.

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[4] Woeikov, A. I. The climates of the world (in Russian). St. Petersburg, 1884, p. 321.

TABLE 3.—*Temperature and relative humidity in Amazon River basin and at points on or nearer the coast*

Locality	Altitude	Latitude	Distance from Atlantic Ocean	Temperature			
				Mean annual	Average for the warmest month	Absolute maximum	Annual mean relative humidity
	Feet	°	*Miles*	° *F.*	° *F.*	° *F.*	*Per cent*
Para	----------	1½	62	80.6	81.86	----------	----------
Manaos	121	3	714	78.98	80.6	97.26	80
Iquitos	311	3½	130	76.64	78.26	90.32	83
Pernambuco	11	8	----------	78.26	80.78	89.06	72
San Antonio on the Madeira	----------	9	1,087	78.8	80.6	----------	----------

Woeikov attributes this remarkably moderate temperature of the Amazon Basin to the cooling effect of the forest, due to the enormous evaporation of water from the soil and plants in the Tropics. He assumes that in tropical countries covered with luxuriant forest vegetation the rainfall is seldom less than about 60 inches a year. So thick usually is the mass of decayed leaf litter and fallen and half-rotted trees in the forest that most of the rainfall is absorbed by the soil, and only a small portion runs off from the surface. Even allowing one-third of the annual precipitation for surface run-off, there is still transpired by the plants and evaporated by the soil a layer of water about 40 inches high. About 35.5 cubic feet of water are given off from every 10.7 square feet, and in the evaporation of this amount of water 606,500 calories of heat are consumed. The cooling of the air due to this evaporation explains why, in the vast tropical forests, the temperature of the air never becomes as high as it is even in middle latitudes.

The evaporation of water from forests differs from evaporation from water surfaces in that, while forests are, during the day, continually using up heat by converting it into latent heat through transpiration, bodies of water are directly heated by the sun's rays, becoming, as it were, temperature reservoirs. Interior seas and lakes in the Tropics are often heated considerably above 82°, and even 86° F., increase the temperature of the lower air when it is cooler than the water.

The total area of the leaves is so great that at night they cool off quickly. When they have reached the dew-point temperature, vapor of the air condenses on their surface. A part of the water which has been transpired during the day is thus brought back to be transpired again next day. The forests may therefore be likened to a self-feeding boiler, the water from which is evaporated into the air at the expense of the heat of the sun and surrounding air.

TEMPERATURE OF THE SOIL

Forests influence the temperature of the soil in almost the same way as they do that of the air. The differences in temperature outside and inside the forest, however, as a comparison of Tables 3 and 4 will show, are greatest in the case of soil.

This is readily explained by the fact that the temperatures of bodies of air near one another tend to become equalized by the passage of air currents. Moreover, the surface of the soil is heated directly by the sun, while the air receives its heat chiefly from the surface of the soil, so that the difference between the temperature of the soil in the forest, where the ground is at least partially protected from heat, and that outside of the forest, where no such protection exists, is especially pronounced. This difference is not limited to the surface of the soil, but is manifest at a considerable depth.

TABLE 4.—*Difference in soil temperatures inside and outside the forest*

	February-April		May-July		August-October		November-January		Mean annual	
	At surface	At a depth of 35.5 inches	At surface	At a depth of 35.4 inches	At surface	At a depth of 35.4 inches	At surface	At a depth of 35.4 inches	At surface	At a depth of 35.4 inches
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
Mountains of Alsace	−1.8	+0.90	−14.04	−5.04	10.26	−5.76	+0.54	−1.26	−6.30	−2.70
Bavaria	−3.24	−1.44	−8.10	−7.02	−4.68	−5.4		−.18	−3.96	−3.96
Do	−2.34	−1.08	−8.28	−7.38	−4.68	−5.4	+.54	−.18	−3.78	−3.6
Eastern Prussia	−2.34		−7.92	−6.48	−4.14	−3.96	+2.34	+1.62	−2.88	−2.16

In winter soil temperatures of the forest and field differ but little. The temperature of the soil in the forest is even somewhat higher, especially where snow lies on the ground for several months, when the difference is considerable. In eastern Prussia, for instance, it amounts to almost 3.6° F. The fluctuations of soil temperature in the forest, therefore, are much smaller than in the field. The moderating influence of the forest upon the temperature of the surface of the soil becomes especially marked when the maximum and minimum temperatures for the entire year are compared. (Table 5.)

TABLE 5.—*Fluctuation of soil temperatures inside and outside the forest*

	Outside the forest			Inside the forest		
	Maximum	Minimum	Fluctuation	Maximum	Minimum	Fluctuation
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
Bavaria (6 stations)	84.02	12.92	71.10	71.24	18.14	50.10
Mountains of Alsace	86.00	23.00	63.00	63.32	27.68	35.64
astern Prussia (2 stations)	81.68	6.44	75.24	64.58	16.52	48.06

More recent observations upon the temperature of the soil inside and outside of the forest yielded results very similar to the earlier ones. These later results show that the forest soil is warmer in winter by 1.8° F. and cooler in summer by from 5.4° to 9° F. than soil without a forest cover, and that this holds true for a depth of as much as 4 feet. In the spring, and especially in the summer, the forest soil is cooler than that of open land. In the fall and winter, however, it is warmer, but the degree of difference is always less than in summer.

Observations in 1892 and 1893 at L'Adlisberg, near Zürich,[5] showed that under the complete cover of a young beech stand the average temperature of the soil from April 1 to November 1 was from 9° to 12.6° F. lower than in the open on level ground, and from 10.8° to 18° F. lower than on ground sloping toward the south, but otherwise almost identical. On August 24, 1894, the soil on an open southerly slope attained a temperature of 91.4° F. Under the forest, close by on the same slope, the temperature was only 63.3° F. A cover of young beeches thus produced a soil temperature lower by about 28.1° F. The temperatures were taken at a depth of 2 inches; at the surface the difference was still greater.

The influence which forest cover has upon the freezing of the ground was well brought out by 21 years' observation in Germany,[6] as shown in Table 6.

TABLE 6.—*Freezing of soil inside and outside the forest*

Stations	Altitude, nature of soil, and composition of forest	Depth to which soil freezes		Difference	Depth of frost in forest soil in per cent of depth in the open
		Outside the forest	Within the forest		
		Inches	*Inches*		*Per cent*
Haguenau (Alsace)	Rhine Valley, 492 feet; gravelly sand mixed with humus; Scotch pine.	19.7	8.3	11.4	42
Eberswalde (near Berlin).	160 feet; sandy soil mixed with humus; Scotch pine.	27.6	18.5	9.1	67
Neunath (Lorraine)	Plateau, 164 feet; lime rock; beech	8.7	5.9	2.8	68
Melkerei (Alsace)	Moderate southeast slope, 3,114 feet (167 feet below summit of slope); decomposed granite; beech and fir.	17.7	13.0	4.7	73

Thus, the soil under the forest may remain soft when the ground in the open is frozen hard to some depth. If it does freeze it is to a depth of from one-half to less than three-fourths that in the open.

RELATIVE HUMIDITY

In the summer the relative humidity of the air is higher in the forest than in the open; first, because the transpiration of water by the leaves appreciably increases the moisture content of the air within or near the forest; and, second, because the temperature of the air in the forest is lower, and therefore nearer its saturation point. This difference is usually between 4 and 10 per cent, but in some places may be as much as 12 per cent. In regions of heavy snow there is practically no difference in the relative humidity during the spring, when the snow melts. Table 7 shows the difference between the relative humidity of the air outside and inside the forest for different months of the year.

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[5] Bühler, A. Beobachtungen an den forstlich-meteorologischen Stationen, 1892, 1893. (Mitteilungen der Schweizerischen Centralanstalt für das forstliche Versuchswesen, 1895, vol. 4, pp. 34, 94.)

[6] Schubert, J. Der jährliche Gang der Luft- und Boden-Temperature im Freien und in Waldungen. Berlin, 1900.

TABLE 7.—*Relative humidity inside and outside the forest*

	February-April		May-July		August-October		November-January		Entire year	
	Outside the forest	Inside the forest	Outside the forest	Inside the forest	Outside the forest	Inside the forest	Outside the forest	Inside the forest	Outside the forest	Inside the forest
Mountains of Alsace	80	85	68	75	78	84	85	89	77	84
Bavaria	80	84	70	80	78	85	87	90	79	85
Eastern Prussia	84	85	64	68	76	81	90	92	78	82

PRECIPITATION

The water which reaches the ground and becomes available for vegetation and stream flow comes from two chief sources—first, rain, snow, hail, etc., which form in the upper strata of the air; and, second, dew, hoarfrost, and similar condensations of the air moisture which form on the surfaces of foliage, branches, and trunks, and also on the surface and in the interior of the soil when these are colder than the surrounding air.

EFFECT UPON LOCAL PRECIPITATION

Observations upon the influence of forests on local precipitations began as early as the middle of the last century, but systematic observations did not start until the second half of the sixties (Bavaria, France, and Switzerland), and in many places are still being carried on. In a few cases these observations do not show any essential difference in the amount of precipitation over forest and over open fields. Most of them, however, demonstrate beyond doubt that the amount of precipitation over forests[7] is greater.

This excess of precipitation over forested areas varies from a fraction of 1 per cent to 25 per cent. Such wide variation is due partly to differences of geographic situation, altitude, character of the forest, etc. At the forest experiment station at Nancy, 33 years' observations show an average excess of precipitation on forested areas of 23 per cent, while Ebermayer in Germany, Bouvard at Moumal, and Blandford in India compute it as being 12 per cent. Some meteorologists are inclined to ascribe the difference in the amount of precipitation over forests and open fields to the imperfection of the rain gauges. Hellman's[8] experiments, for instance, showed that the ordinary rain gauge in a wind of medium velocity registers 19 per cent less of precipitation than actually falls. It is possible that rain gauges in the forest, being protected from wind, will catch more rain and therefore show a greater amount of precipitation than when placed in the open. That the greater amount of precipitation over forest areas as compared with open fields can not, however, be ascribed entirely to this, has been clearly brought out by Müttrich, who, during four years of careful observation with Hellman's improved rain gauges, found that the difference of precipitation in the forest and outside the forest still amounted to 6 per cent.

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[7] Blodget, Lorin. Climatalogy of the United States. Phila., 1857; Lorenz-Liburnau, Josef Roman von. Resultate forstlich-meteorologischer Beobachtungen insbeondere in den jahren 1885–1887, pt. 1–2. Wein, 1890–1892. (Mittheilungen aus dem forstlichen Versuchswesen Österreichs, Heft. 12–13); Bühler, A. Beobachtungen an den forstlich-meteorologischen Stationen Adlisberg, etc., 1889–1897. (Schweizerische Centralanstalt für das forstliche Versuchswesen. Mittheilungen, 1891–1898, v. 1, pp. 201–282; v. 2, pp. 61–126; v. 4, pp. 34–173; v. 5, 22–190; v. 6, pp. 18–28); Bühler, A. Die Niederschläge im Walde. (Schweizerische Centralanstalt für das forstliche Versuchswesen. Mittheilungen, 1892, v. 2 pp. 127–160); Hamberg, H. E. De l'influence des forêts sur le climat de la Suède, pt. 4–5. Stockholm, 1896; Blanford, H. F. Influence of the Indian forests on the rainfall. (Asiatic society of Bengal. Journal, pt. 2, 1887, v. 56, pp. 1–15); Studnička, F. J. Grundzüge der Hyetographie des Königreichs Böhmen. (Archiv für naturwissenschaftliche Landesdurchforschungen von Böhmen, 1887, v. 6, No. 3); Fritsch, Karl. Zur Frage über den Einfluss des Waldes auf den Regen. (Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie, 1867, v. 2, pp. 230–235); Krutzch, H. Ueber den Einfluss der Waldungen auf die Regenverhältnisse der gemässigten Zone. (Tharander forstliches Jahrbuch, 1855, v. 11, pp. 123–141); Fautrat, L. Observations météorologiques faites de 1874 à 1878. Paris, 1878; Ebermayer, E. W. Untersuchungs-Ergebnisse über die Menge und Vertheilung der Niederschläge in den Wäldern. (Forstlich-naturwissenschaftliche Zeitschrift, 1897, v. 6, pp. 283–301); Müttrich, A. Bericht über die Untersuchung der Einwirkung des Waldes auf die Menge der Niederschläge. Neudamm, 1903; Hann, Julius. Wald und Regen. (Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie, 1867, v. 2, pp. 129–136); Kopezky, Richard. Wald und Niederschläge. (Centralblatt für das gesamte Forstwesen, May, 1899, v. 25, pp. 195–213, 243–253); Zacher, Gustav. Ueber den Causalnexus von Wald und Regen. (Oesterreichische Vierteljahresschrift für Forstwesen, 1890, v. 40, pp. 103–108); and others in Russian.

French observers are practically unanimous in recording a larger amount of precipitation over forests than over fields. This conclusion is the result of experiments carried on at the forest school at Nancy, in the forests of Haye, by Fautrat in the forest of Halatte (Oise), and by de Pons in the forest of Troncais (Allier). Most of those carried on in Germany, Austria, Russia, and India have forced similar conclusions.

Regular observations taken at Nancy for 33 years since 1866, at stations inside, on the edge of, and outside the forest, show that, without exception, more rain has fallen inside than outside the forest, and that during 8 or 10 years more rain fell on the edge of the forest than outside. If the amount of the rainfall at the center of the forest be designated as 100, then the amount of rainfall at the edge of the forest would be represented by 93.9 and the rainfall outside the forest by 76.7.

The difficulty of bringing out clearly the influence which forests have upon precipitation results from the fact that the bulk of the forests are in the mountains. Altitude, as is well known, has a definite relation to the amount of precipitation, and unless this influence is eliminated that of the forest can not be clearly determined. To neutralize this altitudinal influence Prof. R. Weber[9] has grouped (Table 8) precipitation data obtained during a period of 10 years (1876–1885) at Prussian forest stations situated at different altitudes, together with average figures obtained by Dr. van Bebber[10] from 192 ordinary weather stations within the respective regions at corresponding altitudes but outside the forest.

TABLE 8.—*Precipitation within and outside of the forest at different altitudes*

	Altitude (feet)					
	3–300	330–650	980–1,300	1,970–2,300	2,300–2.600	3,000–3,280
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Stations in the forest (R. Weber)	25.9	26.2	29.4	42.9	55.5	69.9
Ordinary stations (Dr. van Bebber)	25.5	22.9	27.4	36.0	38.6	37.9
Difference	.4	3.3	2.0	6.9	16.9	32.0
Per cent	1.25	14.2	7.3	19.0	43.7	84.2

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[8] Hellman, G. Resultate des Regenmessungs-Versuchsfeldes bei Berlin, 1855 bis 1891. (Meteorologische Zeitschrift, 1892, v. 9, pp. 173–181.)

[9] Weber, R. Die Aufgaben der Forswirtschaft (in Lorey's Handbuch der Forstwissenschaft, 1903, v. 1, pp. 1–102).

[10] Bebber, J. van. Die Regenverhältnisse Deutschlands. München, 1877.

This table shows that, while the rainfall at the forest stations situated in the plains of north Germany exceeds the average for such lands by only 0.4 of an inch, or 1.25 per cent, the excess at moderate altitudes of from 328 to 656 feet amounts to 14.2 per cent. At elevations between 1,970 and 2,300 feet the difference is increased to 19 per cent, between 2,300 and 2,600 feet to 43.7 per cent, and between 3,000 and 3,250 feet to 84.2 per cent. These figures seem to show that the influence of the forest upon precipitation increases with the increase in altitude. Therefore, while it is true that mountains affect precipitation, wooded mountains affect it to a still greater degree. On the other hand, it is not true, as it was for many years commonly believed to be, that the rainfall chart is practically identical with the contour chart. In reality the matter is not so simple.

Angot, in his "Régime des pluies de la peninsule iberique," published in the Annales du Bureau Meteorologique de France, 1893, brings out most strikingly the fact that denuded mountains do not always cause moisture-laden winds to precipitate their moisture. An examination of the monthly and annual mean precipitation during the months of June, July, and August shows it to have an entirely different character from that during the preceding months. In June the fall is from 1 to 2 inches in the northern part of the peninsula and less than 1 inch in the southern part. In July and August only from four-tenths to 1 inch falls in the north and less than four-tenths of an inch in the south. "These three months, therefore, are the driest months, yet," says Angot, "the wind generally blows from the sea during this period, but owing to the excessive heat of the soil the moisture-laden clouds, on arriving inland, are further heated and are therefore further than ever removed from the saturation point. In all this mountainous region, which covers the Provinces of Granada, Jeon, and Murcia, in spite of the proximity of the sea, in spite of the entire absence of mountain ranges to the west which might precipitate the moisture before it reaches here, in spite of the presence within the region of the high peaks, some having an elevation of from 6,500 to 16,400 feet, the rainfall during July and August does not exceed four-tenths of an inch. It is certain that if these mountain ranges, which stretch between Sierra Nevada and Sierra Segura, were wooded instead of being absolutely bare and dry, the precipitation in the southeast of Spain would be increased, and there would be no fear of the disastrous floods which at times occur in the basin of the River Segura."

Wooded mountains, therefore, increase precipitation to a much greater degree than denuded mountains. This effect is especially marked during summer months, and as Fautrat's[11] observations show, the effect is greater over coniferous than over broadleaf forests. The greater effect of coniferous forests upon the amount of precipitation can not be due to transpiration, since coniferous forests, as is well known, transpire less than broadleaf forests. According to Henry,[12] this greater concentration of vapor over coniferous forests must be due to the fact that the crowns of conifers intercept a greater amount of precipitation and therefore return into the atmosphere larger quantities of water than broad-leafed trees. Fautrat's observations in 1876 showed that while the soil under broadleaf forests received 16.7 inches, the soil under coniferous forests received only 11 inches. Therefore 5.7 inches, or 20,608 cubic feet per acre, were retained by the crowns of the conifers and returned into the atmosphere. Similar results were obtained by him in 1877.

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[11] Fautrat, L. Observations météorologiques faites due 1874 à 1878. Paris, 1878, p. 21.

[12] Henry, E. Sur le rôle de la forêt dans la circulation de l'eau à la surface des continents. Paris, 1902, p. 14.

Dr. Paul Schreiber,[13] a noted meteorologist, after working up elaborate meteorological data for Saxony, came to the conclusion that in a region completely covered with forests the influence of the forest in increasing precipitation would be equal to elevating the region 650 feet. A comparison by Prof. R. Weber of the precipitation data for seven years at the French weather stations at Cinq Tranchées and at Amance is shown in Table 9. The two stations lie on an oolitic plateau near Nancy at an elevation of 1,246 feet above the sea. That at Cinq Tranchées is located on a pasture surrounded by large forest areas, while the one at Amance is in a region practically stripped of forest. The results are given for the four seasons of the year.

TABLE 9.—*Precipitation over forest pasture and in treeless region, France*

	Spring	Summer	Fall	Winter	Total
	Inches	*Inches*	*Inches*	*Inches*	*Inches*
Cinq Tranchées (forest station)	6.3	7.4	7.6	8.3	29.6
Amance (not in forest)	5.9	6.5	6.2	7.0	25.5
Difference	.4	.9	1.4	1.3	4.1

The greater excess of precipitation over the forest pasture during fall and winter when the clouds are very low is no doubt the result of condensation due chiefly to the mechanical obstruction offered to the moisture-leaden strata of air.

During the four-year period from 1874 to 1877, Fautrat and Sartiaux conducted experiments on precipitation in the 12,500-acre state forest of Halatte. The experiments were carried on in the space above the tops of trees; in one case 23 feet above a hardwood forest, and in another 10 feet above a coniferous forest, with similar observations in the open. The observations yielded the following results:

	Above tree tops	In the open	Difference
	Inches	*Inches*	*Inches*
Broadleaf	25.8	24.8	1.0
Coniferous	26.3	24.0	2.3

Dr. Müttrich[14] observed at the meteorological station at Lintzel in the Luneburg heath the influence which the planting of a forest in the open waste land has upon the amount of precipitation. Planting was begun in 1877. At that time the region was made up of cultivated land, 12 per cent; heath, 85 per cent; and forest, 3 per cent. After the planting was finished the proportion of forest land had been increased to 80 per cent, and that of heath and agricultural land reduced to 10 per cent each. Regular observations on the amount of precipitation were begun in 1882, and the figures for each year thereafter compared with those for five neighboring stations where conditions had, of course, remained unchanged. For the years 1882–1888, inclusive, the precipitation at Lintzel, expressed in per cent of the average for the five other stations, was 81.8, 86.3, 95.2, 99.8, 100.6, 103.7, and 103.9, respectively. As compared with that at any one of the other stations, in fact, the precipitation at Lintzel showed a steady increase for the seven-year period. This demonstration of the effect of forest cover upon local precipitation is particularly striking.

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[13] Schreiber, P. Die Einwirkung des Waldes auf Klima und Witterung. (Tharander forstliches Jahrbuch, 1890, v. 49, pp. 85–204.)

[14] Müttrich, A. Ueber den Einfluss des Waldes auf die Grösse der atmosphärischen Neiderschläge. Zeitschrift für das gesamte Forstwesen, 1892, v. 24, pp. 27–42.)

A most direct proof, however, of the effect of forests in increasing local precipitation is afforded by observations following forest planting in the steppes of southern Russia. Between 1845 and 1863 over 5,000 acres of forest were planted in an entirely open situation in the high steppes (prairies). About 1892 two meteorological stations were established for determining in a most accurate and thorough manner the climatic influence of the forest. One station was located on the open steppe and the other in the forest. At the first the average annual precipitation during the period between 1893 and 1897 was found to be 17.9 inches, while in the newly established forest it was 22.2 inches, or 23.9 per cent more, in spite of the fact that the station in the open was located somewhat higher than the one in the forest. In addition, eight parallel observations on precipitation in the open and in the forest, carried on elsewhere, showed that the influence of the forest upon the amount of precipitation was greatest at the time of heavy rains, but was also well marked during the dry periods of the year. Thus, while the amount of precipitation at stations in the open during the summer of 1895 was 8.3 inches, that at the forest stations was 9.7 inches, or 16.4 per cent greater. These observations tally with similar ones taken in 1894 and 1895 by J. Klingen in the open steppe and in the neighboring forest of Chrinovsky, in the Government of Voronej.

TABLE 10.—*Precipitation on the open steppe and in pine and oak forest*

	Total for the year		Total for the growing season	
	1894	1895	1894	1895
	Inches	*Inches*	*Inches*	*Inches*
In the open steppe	13.9	14.1	12.0	7.6
In a pine forest	19.9	19.8	15.0	10.1
In an oak forest	21.3	20.7	13.9	10.3
Excess in pine forest over the open, actual	6.0	5.7	3.0	2.5
Excess in pine forest over the open ... per cent	43.0	40.0	25.0	32.0
Excess in oak forest over the open, actual	7.4	6.6	1.9	2.7
Excess in oak forest over the open ... per cent	53.0	46.0	16.0	36.0

The effect of forests upon precipitation, as shown from the data brought together by such meteorologists as Woeikov and Blanford, is even greater in tropical and subtropical climates than in temperate regions. Thus, for British India, Woeikov shows that the forest cover exerts a greater influence upon precipitation than does proximity to the ocean.

TABLE 11.—*Precipitation in forested and treeless regions, British India*

Locality	Distance from sea	Precipitation			
		April	May	June	July
Treeless region:	*Miles*				
Lucknow	526	0.2	0.7	5.0	15.5
Benares	367	.2	.5	5.0	12.9
Patna	276	.4	1.0	6.0	10.9
Berhampur	168	2.2	3.9	9.5	10.1
Forested region:					
Goalpara	265	5.8	13.0	25.3	19.6
Sibsagar	345	10.2	12.0	15.5	15.9

H. F. Blanford, meteorologist to the Government of British India, regards Woiekov's statement as too sweeping, but admits that the forest is one of the elements which contributes to the amount of precipitation over Assam Valley. He furnishes a very striking evidence of the effect of forest protection upon increase in precipitation. In part of the central Provinces of British India a forest area of about 600,000 acres has been protected for a number of years (since 1875) from fire. As a result there appeared, under the thin stands of trees, a dense young growth. Complete precipitation records were kept at seven stations from 1865 or 1867 up to the present time. A comparison between the precipitation before 1875 and after 1875 (Table 12) shows a marked increase in the latter period for the same area.[15]

TABLE 12.—*Precipitation over protected forest area, British India*

Weather stations within the protected region	Observations begun	Mean annual precipitation		
		Before 1875	After 1875	Difference
		Inches	*Inches*	*Inches*
Badnur	1867	39.83	47.83	+8.00
Chhindwara	1865	41.43	48.48	+7.05
Seoni	1865	52.07	54.76	+2.69
Mandla	1867	53.58	56.32	+2.74
Burha	1867	64.51	71.65	+7.14
Bilaspur	1865	41.85	54.81	+12.96
Raipur	1866	51.59	54.41	+2.82
Average		49.27	55.47	+6.20

Practically all observations, then, tend to show that there is an increase in the total amount of precipitation over wooded areas as compared with that over barren or deforested ones. One reason for this is undoubtedly the tendency of moisture-bearing currents to precipitate their moisture more readily above or near the forests than over bare or cultivated fields at the same elevation, due to the dampening and chilling effect of the forest upon the atmosphere, which induces a greater condensation of the water vapor.

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[15] Brandis, D. Regen and Wald in Indien. (Meteorologische Zeitschrift, 1887, v. 4, p. 375.)

That the air over forests contains a much larger amount of moisture than that over bare or cultivated fields is to-day a proven fact, based both on actual observations in the upper air strata and determinations of the quantities of water evaporated by the forest. The latest experiments by Russian agronomists and foresters, corroborated by similar observations in France and Germany, have shown conclusively that in level or slightly hilly regions (where the stratification of the rock is horizontal and the ground waters are stagnant, as, for example, in the steppes of Russia or the landes of Gascony) the forest has a desiccating effect upon the ground, causing the water table to be lower under forest than in adjoining open fields. Professor Henry, in his recent investigations upon the effect of forests upon ground waters in level country, found that the minimum depression of the water table produced by the transpiration of forest trees in the Mondon forest near Luneville, France, amounts to 11.8 inches. With a porosity of the soil strata ranging between 45 and 55 per cent, such depression would correspond to a rainfall of 5.9 inches, which amounts to 21.443 cubic feet per acre.

This amount of water given off by the forest into the air obviously contributes greatly to the moisture content of the atmosphere above the forest. Dr. Franz R. von Höhnel,[16] of the Austrian forest experiment station at Mariabrunn, after observations carried on for a period of three years (1878–1880) upon the amount of water transpired by forests, found that one acre of oak forest, 115 years old, absorbed in one day from 2,227 to 2,672 gallons of water per acre, which corresponds to a rainfall of from 0.09 to 0.115 per day, or 2.9 to 3.9 per month. Taking the period of vegetation as five months, the absorption of water would be 158,895 cubic feet, which represents a rainfall for this period of 17.7 inches. This amount of water is given off through transpiration from the leaves and does not include the physical evaporation from the surface of the twigs, branches, and leaves. These figures, while only approximate, give an idea of the enormous quantities of water given off by forests into the air, which has justly given them the name of the "oceans of the continent."

As a matter of fact, small clouds are frequently observed hanging persistently over forested areas in the presence of a fairly strong wind. If all the moisture given off by the forest could be made visible as a fog, heavily forested areas would appear enveloped by a damp mist, more dense over coniferous than over broadleaf forests.

That the vertical influence of the forest extends to a height far greater than 100 or 200 feet has been proven by observations taken during balloon ascensions. Thus Renard, commander of engineers and subdirector of the Central Military Balloonist Institute of France, states that the effect of the forest upon the temperature of the upper strata of air has been repeatedly felt during ascensions at an elevation of nearly 5,000 feet over the forest of Orleans, which has an area of 75,000 acres. This influence is scarcely felt over field crops, and it is obvious that the difference can not be due to the greater height of the trees, which at best reach but a little over 100 feet on an average. It can be accounted for only by the greater amount of water given off by the forest and the lower temperature above it.

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[16] Höhnel, F. R. von. Ueber die Transpirationsgrössen der forstlichen Holzgewächse. (Mitteilungen aus dem forstlichen Versuchswesen Oesterreichs, 1881, v. 2, pp. 47–90, 275–296.)

The condensation of vapor on the surface of the leaves in the form of dew, hoarfrost, etc., in northern latitudes, according to C. E. Ney.[17] is from 0.4 to 0.8 inch a year. It is much more in southern latitudes, especially in tropical forests. The condensing capacity of many tropical forests, because of the extreme dampness of the air within them, is so great that during every clear and still night drops of dew fall continuously from the leaves as in rain. (This is also the case in the redwood belt on the Pacific coast.) Thus part of the moisture which is evaporated from the leaves during the day is condensed during the night, and the dews in the forest in all latitudes are so heavy that they dampen the soil under the leaves.

Condensation formed within the soil may be omitted from this discussion, judging from the results of local observations over limited areas, since there seems to be no difference in this respect between open field and forest.

Another reason for greater precipitation over forests may be the mechanical action of the trees themselves. When a cloud in the mountains passes through a forest, the branches and the leaves of the trees retard its movement. It comes, therefore, into a state when it can no longer retain its moisture in suspension, just as a river carrying sediment deposits part of it as soon as the rapidity of its flow is diminished. The moisture from such clouds is intercepted by the forest in the form of mist or drops of dew or crystals of hoarfrost on the branches and foliage of trees.

The mechanical action of the forest is especially important in the case of snow. The influence of forests upon the amount of snow has been especially studied in Russia, where in some places more than 30 per cent of all the precipitation is in that form. During heavy storms the forests not only catch more snow than do large open fields, from which it is blown away, but they prevent it drifting. There is always more snow deposited within the forest than in nonforested areas, except in depressions and protected places where snow accumulates. In regions where the snowfall is heavy the amount of snow that accumulates in the forest, and especially in small openings within the forest, is often so great that gauges located even under the crowns of trees contain more snow than those located in large open places, in spite of the fact that snow is very readily retained by the branches, especially in coniferous forests, and that part of the snow thus retained by the trees gets into the rain gauges only at the time of thawing, and therefore can not be accurately recorded. The results of many years of observations in Russia upon the accumulation of snow in the forest and outside if it have conclusively shown that young forests, deciduous forests, and small openings within the forest collect nearly twice as much snow as open fields.

After all, it really matters very little for the final result whether the increased precipitation over the forest is due to its influence upon the condensation of vapor in the air or to the mechanical action of its branches and leaves. The fact remains that forests receive more precipitation than open fields.

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[17] Ney, C. E. Der Wald und die Quellen. Tübingen, 1893.

PRECIPITATION OVER CONTINENTS

The effect of the forest upon local precipitation, however, is insignificant as compared with its effects upon the precipitation over the interior of continents.

The moisture given off into the atmosphere by forests is carried great distances over the country or out to sea before it appears as rain; yet, owing to the enormous quantities of water given off by the forest, the amount of moisture in the air, and consequently the chance for rain, is increased. So widely distributed is this influence, however, that even the most exact observations could never determine its extent. The great drawback to local observations, on the other hand, is that the neighboring open areas, the climate of which is compared with that of the forest, are themselves under the influence of the forest.

Prof. Lorentz Liburnau, at the end of his book on Forest, Climate, and Water, remarks that his data and conclusions apply only to the influence which the forest exerts while it exists, but do not extend to conditions which may arise from its complete destruction. "If, for instance, according to our observations in the Carpathian foothills, it appears that the influence of the forest upon the neighboring country is only insignificant, this does not indicate that a complete destruction of all the existing forests will produce here also only insignificant climatic changes. Very likely, if the forest were completely destroyed, the difference would be much greater than that which now exists between the climate of the forest and its neighboring areas."

Source of atmospheric moisture over the land.—While definite observations to show the relation between the forest and the climate of continents are still lacking, there are many theoretical considerations which strongly point to a distinct influence of the forest, especially upon the climate of large continents of a level character.

The accompanying maps, on which the direction of the prevailing winds is indicated by arrows and the mean precipitation by lines, one typical of the summer period and the other of the winter, show a most intimate relation between the prevailing winds and precipitation in the eastern half of the United States. A high meteorological authority in this country states that the "precipitation in the eastern half of the United States is from the aqueous vapor that is raised up from the vast waters to the south and southeast of the continent," and that "the supply is inexhaustible." [18]

If by this is meant that the precipitation over the eastern part of the United States is derived entirely from evaporation from the Gulf of Mexico and the Atlantic Ocean, the statement is not entirely correct. It is true that the southern winds which prevail all over the eastern United States during the summer pass over the Atlantic Ocean and the Gulf of Mexico and reach the land loaded with moisture. As soon, however, as they reach the land, part of the moisture is precipitated, and as they move farther inland they become drier and derive their moisture more and more from the evaporation from the land.

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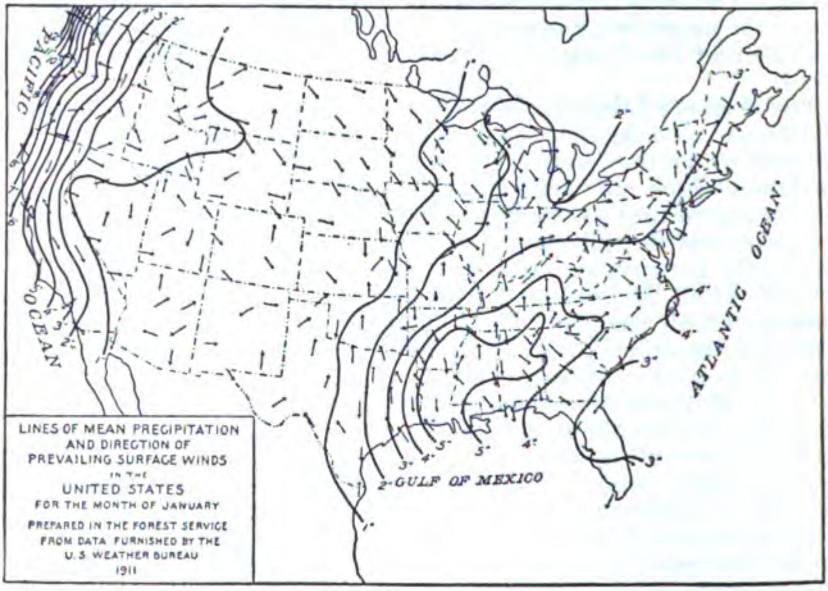
[18] Moore, W. L. A report on the influence of forests on climate and on floods. Washington, D. C., 1910.

Of the 44,015,400 square miles of land surface of the earth 79 per cent drains directly toward the ocean and 21 per cent forms an inclosed inland area without ocean drainage. The 79 per cent may be called the peripheral area of the earth's surface, and the importance of the evaporation from it is, on the whole, very great.

Prof. Ed. Brückner[19] computes the "continental vapor" evaporated from this peripheral area to be about 21,000 cubic miles (20,871.3 cubic miles). It plays, therefore, even a more important part in supplying moisture to the air than does the vapor directly evaporated from the ocean. Brückner estimates that the peripheral regions of the continents are capable of supplying seven-ninths of their precipitation by evaporation from their own areas. If the evaporation from land plays such an important part in the precipitation over areas adjoining the ocean, it becomes still more important at some distance from the ocean. It may be assumed, therefore, that the moisture which is carried by the winds into the interior of vast continents, thousands of miles from the ocean, is almost exclusively due to continental vapor and not to evaporation from the ocean.



LINES OF MEAN PRECIPITATION AND DIRECTION OF PREVAILING SURFACE WINDS IN THE UNITED STATES FOR THE MONTH OF JANUARY

PREPARED IN THE FOREST SERVICE FROM DATA FURNISHED BY THE U. S. WEATHER BUREAU 1911

In the interior closed basins the precipitation and evaporation are, as a rule, equal.

The circulation of water on the earth's surface may be shown in the form of a balance sheet, as follows:

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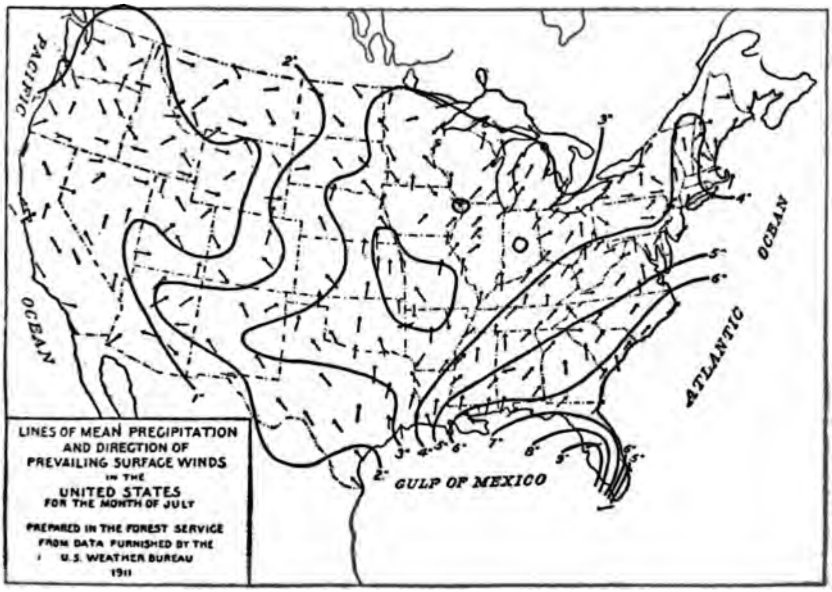
[19] Brückner, E. Die Bilanz des Kreislaufs des Wassers auf der Erde. (Geographische Zeitschrift, v. 6; also in La Pedologie (Russian), 1905, v. 7, No. 3.)

Balance sheet—Circulation of water on the earth's surface

	Cubic miles	Depth, in inches	Per cent
A. Entire earth surface (196,911,000.59 miles):			
Evaporation from water surfaces	92, 121	29. 5	80
Evaporation from land surfaces	23, 270	7. 5	20
Precipitation on entire earth surface	115, 391	37. 0	100
B. Oceans (141,312,600 square miles):			
Evaporation from oceans	92, 121	41. 3	100
Amount of ocean vapor carried to the land (net [1])	5, 997	2. 8	7
	86, 124	38. 5	93
C. Peripheral land area (44,015,400 square miles):			
Ocean vapor (net)	5, 997	8. 7	29
Continental vapor from the peripheral land surface	20, 871	29. 9	100
Precipitation over the peripheral land area	26, 868	38. 6	129
D. Closed interior basins with no drainage to the ocean (11,583,000 miles):			
Evaporation from closed basins	2, 399	13. 0	100
Precipitation over closed basins	2, 399	13. 0	100

[1] The difference between the amount of vapor that escapes from land to the ocean and from the ocean to land.

An analysis of these figures discloses the fact that one-fifth of the entire vapor on the earth's surface comes from evaporation on land; that only 7 per cent, or 5,997.5 cubic miles, of all the water evaporated from the oceans enters into the precipitation over land; and that 78 per cent of all the precipitation that falls over the peripheral land area is furnished by this area itself.



Where is evaporation on land greatest? The evaporation from a moist, bare soil is, on the whole, greater than from a water surface, especially during the warm season of the year when the surface of the soil is heated. Soil covered only with a dead vegetable cover evaporates moisture much more slowly than a bare soil or an open water surface. On the other hand, a soil with a living vegetal cover loses moisture, both through direct evaporation and absorption by its vegetation, much faster than bare, moist soil.

The more highly developed the vegetal cover the faster is moisture extracted from the soil and given off into the air. In this respect the forest is the greatest desiccator of the soil. The experiments of Otozky, which have been fully confirmed by many observers in other countries, have conclusively shown that the forest, on account of its excessive transpiration, consumes more moisture, all other conditions being equal, than a similar area bare of vegetation or covered with some herbaceous growth.

The amount of water consumed by the forest is nearly equal to the total annual precipitation—in cold and humid regions less and in warm and dry regions somewhat greater. This enormous amount of moisture, which is later given off into the air by the forest, may be compared to clouds of exhaust steam thrown into the atmosphere, and must necessarily play an important part in the economy of nature. If the south and southeast winds, in their passage toward the north, northwest, and northeast, in the spring and summer, did not encounter the vast forest areas bordering the shores of the Gulf of Mexico and the Atlantic coast, and those of the Southern Appalachian, and, therefore, were not enriched with the enormous quantities of moisture given off by them, the precipitation in the Central States and the prairie region would probably be much smaller than it is now. The central interior region of the United States is the battle ground of two titanic forces, one harmful, the other beneficial. The beneficial one takes the form of the mild and humid summer winds from the Gulf of Mexico and the Atlantic Ocean, which at their height extend into the continent as far north as North Dakota, as far west as the foothills of the Rocky Mountains, and as far east as New England, and during the prevalence of which the rainfall in the eastern United States is heaviest. The other and harmful force is made up of the warm chinook winds which blow out of the northern Rocky Mountains, and the dry westerly winds of the upper Mississippi and the western lake region, both of which carry in their wake serious injury to orchards and fields. The Central States and the prairie region are geographically at the point where the battle between the two forces is fiercest, and the victory is now on one side, now on the other. When the humid southerly winds extend their influence far into the interior of the continent and overpower the dry continental winds, the Central States and prairie region, the granary of the United States, produce large crops. When the dry winds overpower the humid southerly winds there are droughts and crop failures.

As soon as the moisture-laden winds from the Gulf reach the land and encounter irregularities they are cooled and begin to lose part of their moisture in the form of precipitation. As long as the air currents remain saturated with moisture the slightest cooling or irregularity of the land that causes them to rise will result in precipitation. But as they move inland and become drier the remaining moisture is given off with difficulty and precipitation decreases. The sooner the humid air currents over land are drained of their moisture, the shorter, of course, is the distance from the ocean over which abundant precipitation falls. If precipitation over land depended solely on the amount of water brought by the prevailing winds directly from the ocean, rainfall would, of course, be confined only to a narrow belt close to the sea. Not all the water that is precipitated, however, is lost from the air current. A large part of it is again evaporated from the land into the atmosphere. The moisture-laden air currents, therefore, soon lose the moisture which they obtain directly from the ocean, but in moving farther into the interior absorb the evaporation from the land. Hence, the further from the ocean the greater is the proportion which evaporation from the land forms of the air moisture. In fact, at certain distances inland practically all the moisture of the air, or at least as great a part as that formed originally by the water evaporated direct from the ocean, must consist of that obtained by evaporation from the land.

In the case of the central and plain States, then, what would be the effect upon precipitation of complete or even partial destruction of forests in the Atlantic plains or in the southern Appalachians? Since the mean temperature in the eastern portion of the United States drops rapidly from north to south, the moisture-laden air currents, upon reaching the land, would be cooled off and rapidly drained of their moisture within a comparatively short distance from the ocean. The sandy soil so characteristic of the southern pine belt of the Gulf and South Atlantic States would rapidly absorb the rain, without returning much of it into the atmosphere. The rain which fell upon the slopes of the mountains would rapidly run off into the streams. While the removal of the forest might increase the evaporation from the ground itself, yet the more rapid run-off and the absence of transpiration by the trees would reduce the total amount of water evaporated into the atmosphere. The land, even if taken up for agriculture, could never return such large quantities of rain into the atmosphere as the forests did. The result would be that less moisture would be carried by the prevailing winds into the interior of the country, and therefore less precipitation would occur there.

Regarding Sweden, an eminent meteorological authority, Doctor Hamberg,[20] says:

"The excess of evaporation which the forest vegetation of Sweden furnishes to the atmosphere above what the same area would furnish if it were covered only with herbaceous vegetation must, of course, be very considerable. If this aqueous vapor remained in the forest and returned to the land in the form of rain, it would be extremely beneficial. But winds carry it on and spread it in all directions with such rapidity that its beneficial influence for our country (Sweden) remains very doubtful."

The forests of Sweden have, however, an important influence upon the precipitation of the countries to the east, into which the prevailing winds blow, since in regions far removed from the ocean the feeding of the atmosphere by local evaporation has an important bearing upon the humidity and amount of precipitation. "On the continents, in countries like central Siberia," says Hamberg, "forest vegetation must influence, of course, the humidity of the air. It returns to the atmosphere in the form of vapor the water collected and conserved in the forest which otherwise would run off. It lowers the temperature of the air. As a result of these two causes, the relative humidity of the air must increase, and with it must also increase the inclination to precipitation in the form of rain or snow."

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[20] Hamberg, H. E. De l'influense des forêts sur le climat de la Suède. Stockholm, 1885–1897.

Whether mountain forests have the same effect as forests in level countries upon the precipitation of the regions into which the prevailing winds that pass over them blow, is difficult to determine. The problem is complicated by the fact that high mountain chains themselves exert an influence upon precipitation and the direction of the winds, not only by presenting a mechanical obstruction to the free passage of the air, but also on account of the difference in temperature on the different slopes. A moist current of air in passing over a mountain chain undergoes several changes. In ascending it becomes cooler, the temperature of air not fully saturated decreasing 1° F. for every 182 feet of ascension. At the same time, the water-holding capacity of the air decreases until the saturation point is reached, and fogs, clouds, and precipitation begin to form. Further cooling of the air in its upward course is counteracted to some extent by the heat that is separated in the process of condensing vapor, and from then on proceeds only at the rate of about 0.5° F. for every 182 feet of ascension. After the air current has passed the crest of the mountain and lost an amount of moisture in ratio to the degree to which it has been cooled, it descends on the leeward side and becomes heated. In its descent it absorbs the fogs and clouds, and in this process takes on some heat. Further heating goes on at the rate of 1° F. for every 182 feet of descent.

The more moisture the air loses in ascending a mountain the greater is the amount of heat it can absorb in descending. If, for instance, a current of saturated air, before ascending, had a temperature of 50° F., and the crest over which it passed was 9,900 feet high, then, on the leeward side at the same altitude at which it began to ascend, it would have a temperature of 77° F. and, provided no moisture is absorbed in the descent, a relative humidity of 21 per cent.[21] At other obstructions met by the same current of air the same changes would take place, though on the next chain of mountains new precipitation begins, as a rule, only at an altitude equal to that of the crest of the previous mountain chain over which the current of air has passed.

Professor Mayr[22] has shown that wherever, as on the Pacific coast, in the Rocky Mountains, and in Caucasus and Turkestan, there are several parallel chains of mountains at right angles to the moist air current, each chain higher than the previous one, the forest on each consecutive mountain chain does not extend below an altitude equal to that of the preceding chain. Between the mountain chains are treeless, dry valleys.

As a rule the moist air currents passing over wooded slopes, being chilled, deposit most of their precipitation on the windward side.

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[21] Klossovsky, A. V. Osnovi meteorologii. Odessa, 1910, p. 48.
[22] Mayr, H. Waldungen von Nord Amerika, Munich, 1890.

It is only in exceptional cases, such as when the air is not fully saturated, or when warm currents rise from below, that the air current, instead of depositing moisture, becomes enriched with moisture and carries it over the crest to the regions lying beyond. This may occur on southern slopes, which are likely to be warm. The influence of wooded windward slopes upon the humidity of the region to the leeward side of the mountains therefore varies. It is apparent, however, that while the forests in the mountains have a marked influence upon local precipitation, their influence upon the humidity of regions lying to the leeward can not, on the whole, be very great.

SUMMARY OF EFFECTS OF FORESTS UPON CLIMATE

Accurate observations, continued for many years in different parts of the world, establish with certainty the following facts in regard to the influence of forests upon climate:

The forest lowers the temperature of the air inside and above it. The vertical influence of forests upon temperature extends in some cases to a height of 5,000 feet.

Forests increase both the abundance and frequency of local precipitation over the areas they occupy, the excess of precipitation, as compared with that over adjoining unforested areas, amounting in some cases to more than 25 per cent.

The influence of mountains upon precipitation is increased by the presence of forests. The influence of forests upon local precipitation is more marked in the mountains than in the plains.

Forests in broad continental valleys enrich with moisture the prevailing air currents that pass over them, and thus enable larger quantities of moisture to penetrate into the interior of the continent. The destruction of such forests, especially if followed by weak, herbaceous vegetation or complete baring of the ground, affects the climate, not necessarily of the locality where the forests are destroyed, but of the drier regions into which the air currents flow.

While the influence of mountain forests upon local precipitation is greater than that of forests in level countries, their effect upon the humidity of the region lying in the lee of them is not very great.

Forests as Conservers of Precipitation

WATER AVAILABLE FOR STREAM FLOW

All the water precipitated over an area covered with vegetation does not go to swell the underground drainage which feeds the springs and the regular flow of streams. Some of it is dissipated before it has a chance to reach the lower strata. A part (i) is intercepted by the branches and leaves of vegetation and is evaporated from them into the air; another part (e) is evaporated from the surface of the soil; a third part (r) runs off from the surface of the slopes into the valleys below; and a fourth part (t) is absorbed by plants and used by them for the building up of tissue and transpiration. Finally, a surplus (S), which is left over and above the amount absorbed by plants and evaporated by the soil, filters through into the ground and enriches the water which goes to supply the streams. Thus the water balance of any given area may be expressed in the form of an equation, in which $P=i+e+r+t+S$, and the amount of precipitation available for stream flow may then be expressed as $S=P-(i+e+r+t)$. Thus it is evident that, since the water available for streams is the amount which is left over and above that evaporated, transpired, and lost through surface run-off, the smaller the loss of atmospheric precipitation, the greater will be the amount of water that penetrates into the ground and becomes available for stream flow. Hence, to determine the effect of forests upon stream flow, it is necessary first to determine whether a greater or less amount of precipitation is dissipated in a forested than in a treeless region.

In a level country, where there is practically no surface run-off, the only sources of loss of water to the streams are interception by vegetation, evaporation from the soil, and transpiration. The water available for stream flow in a level country, therefore, may be represented by the equation $S=P-(i+e+t)$. In mountainous regions, on the other hand, surface run-off is one of the largest sources of loss to ground waters, and the hydrophysical influence of the forest in mountainous country is therefore essentially different from that in level country.

EFFECT OF FORESTS IN LEVEL REGIONS

The forest, all other conditions being equal, has an influence distinct from that of any other vegetable cover upon the amount of precipitation lost to the streams. This influence varies, of course, with the kind of forest, just as the influence of field crops or of bare soil varies in accordance with the character of each.

INTERCEPTION BY TREE CROWNS

On bare ground—for instance, on a plowed field—it is self-evident that no water is lost through interception by vegetation. In a field or meadow from which the grass or crops have been removed interception by the vegetal cover is very slight. It is greater on fields with growing crops, and is greatest in the forest, especially when the trees are in leaf.

Many experiments have been carried on in different parts of the world to determine the amount of water intercepted by the crowns of trees. The results obtained vary considerably with the character of the trees, their age, density of crown, the amount and severity of precipitation, velocity and direction of the wind, etc. The amount of water retained by tree crowns is, however, not much greater than that retained by a meadow of dense grass or cultivated plants at the time of their full development. Ney[23] estimates, on the basis of the average number and weight of beech leaves shed, that the aggregate foliage of a middle-aged beech forest on 1 acre would occupy 8.4 acres, and on the basis of the average yield of straw and hay, that the aggregate area occupied by the foliage of cereals would be 7.4 acres; of clover, 5.6 acres; and of meadow grass, 4.8 acres. Though cultivated plants present less surface per acre than do beech leaves, the latter offer more mechanical hindrances to the run-off of the water. It is very likely, therefore, that during the summer months cultivated fields retain as much water as does a beech forest.

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[23] Ney, C. E. Der wald und die Quellen. Tübingen, 1893.

For the entire year, however, the tree tops intercept more water than field crops, which are present for only a few months. The foliage in deciduous forests, on the other hand, remains intact for six months, and in coniferous forests all the year around. In deciduous forests, even when the foliage is gone, the branches still prevent a portion of the precipitation from reaching the ground directly. As a result of a great number of investigations,[24] it may be assumed that coniferous forests intercept more precipitation than broadleaf forests. Under average conditions a spruce forest will intercept about 39 per cent of the precipitation, a broadleaf forest about 13 per cent. The amount of precipitation intercepted is the smallest in a young stand and greatest in a middle-aged one. This fact is clearly brought out by investigations conducted by Doctor Bühler in Switzerland in dense beech stands of different ages. The figures given in table 13 are averages for two to three years' observations:

TABLE 13.—*Interception of precipitation by tree crowns in beech stands of various ages*

	Age of stand			
	20 years	50 years	60 years	90 years
	Per cent	*Per cent*	*Per cent*	*Per cent*
Proportion which reached the ground	98	73	77	83
Proportion retained by the tree crowns	2	27	23	17

The interceptive influence of forests is much greater in light than in heavy rains. It is evident, therefore, that all the figures which show the interceptive influence of tree crowns have a value only for the place and time that the measurements were taken, and for this reason can not be of general application. In regions where the precipitation is in the form of heavy or prolonged rains the ground under the forest, no matter whether the latter is deciduous or coniferous, will receive as much or nearly as much water as the bare ground, while in regions where the rains are neither heavy nor of long duration a large portion of the precipitation will remain in the tree crowns and escape the soil.

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[24] Hoppe, E. Hegenmessung unter Baumkronen, Vienna, 1896; Fautrat, L. Influence comparée des bois feuillus et des bois résineux, sur la pluie et sur l'etat hygrométrique de l'air (Académie des science, Paris, Comptes rendus, 1877); Fautrat, L. Observations méterolîgique faites de 1874 à 1878. Paris, 1878; Krutzsch, H. Ueber den Einflus der Waldungen auf die Regenverhältnisse der germässgten Zone. (Tharander forstliches Jahrbuch, 1855, v. 11, pp. 123–141); Ebermayer, E. Die physikalischen Ein wirkung des Waldes auf Luft und Boden. Berlin, 1873; Bühler, A. Die Niederschläge im Walde. (Schweizerische Centralanstalt für das forstliche Versuchswesen. Mitteilungen, 1892, v. 2. pp. 127–160); Ney, C. E. Ueber die Messung des an den Schäften der Bäume herabfliessenden Regenwassers. (Mitteilungen aus dem forstlichen Versuchswesen Oesterreichs, 1894, no. 17, pp. 115–125); Johnen, A. Comparative Beobachtungen der Neiderschläge nach Fautrat's Methode. (Centralblatt für das gesamte Forstwesen, 1878, p. 16–19); Riegler, W. Beobachfungen über die Abfuhr meteorlogischen Wassers entang den Hochstämmen (Mitteilungen aus dem forstlichen Versuchswesen Oesterreichs, 1881, v. 2, pp. 234–246); Mathieu, J. Météorologie comparée, agricole et forestière. Paris, 1878; Ebermayer, E. Untersuchungs-Ergebnisse über die Menge und Vertheilung der Niederschläge in den Wäldern (Forstlich natürwissenschaftliche Zeitschrift, 1897, v. 6, pp. 283–301).

Of the precipitation intercepted by branches and leaves, however, only a part is evaporated into the air and so lost to the soil; the rest runs along the branches and trunks down to the ground. The amount of precipitation which reaches the ground along the twigs and trunks varies with the species, the bark, and character of branching. Thus, in a coniferous forest, the amount of precipitation which reaches the ground along the branches and trunks is very small (0.7 to 3 per cent), while in deciduous forests, under average conditions, it is about 15 per cent. Ney, after deducting from the amount of precipitation retained by the tree crowns the amount of water which runs down the trunks and branches, computed the loss of precipitation for the whole year, through interception by the crowns, to average for beech forests, 15 per cent; for pine, 20 per cent; and for spruce, 33⅓ per cent. Mathieu, at Nancy, on a basis of 11 years' observations, found that a forest of blue beech intercepts by its foliage and returns into the atmosphere on an average 8.48 per cent, and in winter only 5.85 per cent of the precipitation.

That portion of the precipitation which is prevented from reaching the ground directly is, however, not lost to the forest. Its evaporation increases the relative humidity of the air, which, together with the lower temperature within the forest, results in the condensation, especially in a coniferous forest, of a great deal of moisture, in the form of fog, dew, and hoarfrost.

Thus, though the forest, more than any other vegetable cover, intercepts atmospheric precipitation and prevents it from reaching the ground, the amount of precipitation thus lost is offset, except in dense, old stands of pure spruce, by the greater precipitation over the forest and the greater condensation of vapor within it in the form of dew, hoarfrost, etc.

EVAPORATION FROM THE SOIL

The influence of the forest upon evaporation has been determined for both water and soil surfaces. Numerous experiments on evaporation from water surfaces outside and inside the forest[25] have been carried on in France, Germany, and Russia. All these give practically the same result, namely, that evaporation from a free water surface is two and a half times greater outside the forest than inside.

Though investigations on the evaporation of water from soil surfaces were begun in the eighteenth century, and there are on record at least 50 different experiments, the results are less conclusive than those relating to the evaporation from free water surfaces.[26] According to the most accurate investigations, evaporation from bare soil in the open, under average conditions, amounts to about 50 per cent of precipitation. This ratio, however, varies within very wide limit. Ebermayer[25] and Wollney,[27] whose experiments are among the most accurate, determined in one case the evaporation from a bare sandy soil in the open to be 33.6 per cent of the precipitation, and that from a clayey soil, 50.8 per cent. In another experiment, where the kind of soil was not given, the evaporation was 49.4 per cent. Comparative observations on the amount of water evaporated by soil within the forest and in the open have been carried on chiefly by Professor Ebermayer. These observations were made only during the summer on soils always kept at the point of saturation. The absolute figures, therefore, must be taken with considerable caution, but the ratio between the evaporation from soil in the forest and from a similar soil in the open which they show is extremely important. This is that the evaporation from forest soil without a cover of leaf litter is 39 per cent, and with a cover of litter 15.4 per cent of the amount evaporated by a similar soil in the open. If the same ratio holds for winter, then, within the forest, a soil covered with leaf litter evaporates only 7.7 per cent, and one without litter 19.5 per cent of the total annual precipitation.

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[25] Ebermayer, E. Die physikalischen Einwirkung des Waldes auf Luft und Boden. Berlin, 1873.

[26] Ezera, K. Untersuchungen über den Einflus der physikalischen und chemischen Eigenschaften des Bodens auf dessen Verdunstungsvermögen. Erlangen, 1844; Mangin, A. Influence des forêts sur le régime des eaux. (Revue des eaux et forêts, 1869.)

[27] Wollney, E. Des Einfluss der Pflanzendecke und der Beschattung auf die physikalischen Eigenschaften des Bodens. Berlin, 1877.

It is fair to assume that in a pine forest which thins out with age the evaporation from the soil will be above the average. In a beech or other deciduous forest, with heavy, dense foliage, it will be less than the average.

Ney[28] determines the evaporation from the soil in a beech forest with leaf litter to be 6 per cent of the precipitation, without a leaf litter 15 per cent; in a pine forest with a leaf litter 15 per cent, without leaf litter 24 per cent; in a spruce forest with leaf litter 8.1 per cent, without leaf litter 19.5 per cent.

The evaporation from soil in an open field covered with some vegetation has never been accurately determined, but, according to Ney, it scarcely exceeds one-third of the precipitation.

These results only confirm what one would expect of the influence which the forest has upon evaporation. The rate at which water is evaporated from the surface depends on the temperature of the air and soil, relative humidity of the air, movement of the air, and character of the soil cover. It has already been pointed out that the temperature of the air throughout the entire year and that of the soil in summer is lower within the forest than in the open, and that the relative humidity, especially in the summer, is greater in the forest than outside of it.

Wind.—The wind exercises a great influence on evaporation, both in summer and winter, by constantly renewing the air in contact with the moisture-containing surface. By breaking the force of the wind and checking the circulation of air, a forest cover reduces the evaporation of water or snow from the forest soil.

Mr. F. H. King,[29] of the agricultural experiment station of the University of Wisconsin, carried on in 1894 a number of interesting experiments to determine the effect of winds upon the rate of evaporation within and outside the sphere of influence of woods. The first series of experiments was made to the northwest of Plainfield, on a piece of ground planted to corn, south of a grove of black oaks having an average height of from 12 to 15 feet. At the time of the experiment there was a gentle breeze from a little west of north. The results showed in one case that the evaporation at 20 feet from the wood was 17.2 per cent less than at 120 feet. In another case, at three stations located within 60 feet of the woods, the amount of evaporation was 24 per cent less than at three stations located between 280 and 320 feet away from the woods. Another experiment near the town of Almond, to the south of an oak grove 80 rods square, in a field sowed to oats and wheat, showed that the amount of evaporation increased until a point 300 feet from the woods was reached. Here the evaporation was 17.7 per cent greater than at 200 feet and 66.6 per cent greater than at 20 feet from the woods, the difference being due entirely to the protection from the wind afforded by the forest.

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[28] Ney, C. E. Der Wald und die Quellen. Tübingen, 1893.

[29] King, F. H. Influence of woods on the rate of evaporation and amount of moisture in the air over fields to the leeward of them. (Wisconsin—Agricultural experiment station. Bulletin 42, 1894, pp. 14–19.)

Observations made by the Forest Service on the influence of windbreaks[30] upon crops have shown that the per cent of moisture saved within an area twelve times as wide as the height of the trees may amount at different wind velocities to from 11 to over 40 per cent.

Character of soil cover.—As already shown, the soil cover in the forest, composed of a mulch of fallen leaves and humus, reduces considerably the amount of moisture evaporated from the ground. Experiments conducted by Professor Ebermayer for five years (1869–1873) in Bavaria demonstrated that a layer of fallen leaves is capable of reducing evaporation from the soil by 24 per cent. Thus, while the average evaporation from the soil in the forest deprived of leaf litter during the summer months (May to September) amounted to 39 per cent of that in the open, the evaporation from the same soil covered with a fairly deep layer of leaf litter was only 15 per cent of that in the open. In other words, while the forest cover alone diminished the evaporation from the ground by 61 per cent, the forest cover, together with the leaf litter, reduced it by 85 per cent.

Evaporation from soil in the open decreases greatly, of course, with increase in altitude; yet the forest cover, together with the leaf litter still exercises its influence, although the difference between the evaporation in the open and that in the forest at high altitudes is not so great as at lower ones.

The lower summer temperature of the soil and air in the forest, the greater relative humidity of the air, the checking of strong air currents, together with the double protection afforded to the soil by the mulch of fallen leaves and humus and the tree tops, tend to reduce the direct evaporation from the soil in the forest to practically a negligible quantity as compared to that in the open.

TRANSPIRATION

Besides the loss of water through direct evaporation from the soil, a large amount is returned to the atmosphere by the transpiration of leaves. This may be called physiological evaporation, in distinction from physical evaporation, since it is essential to the physiological function of the tree.

Loss of water through transpiration is one of the most complicated physiological processes. Although the problem has received a great deal of attention and has been studied by a large number of investigators, the exact quantities of water transpired by different trees and plants are still unknown. What the experiments thus far have established are the comparative amounts transpired by different plants. Of the experiments carried on upon the amount transpired by forest trees those of Wollny, Höhnel, and Bühler are the most valuable, since they were carried on for long periods of years and with the utmost care.

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[30] Bates, C. G. Windbreaks: their influence and value. Wash., D. C., 1911. (U. S.—Dept. of Agriculture—Forest service. Bull. 86.)

Höhnel determined the consumption of water by forest trees by repeated weighings of the pots containing them, and determined the loss of water through transpiration by the difference between successive weighings.

In Table 14 are brought together the results of Höhnel's experiments. The table is of especial interest in that it gives the comparative water consumption of different species. The figures are only for the vegetative season and show the number of pounds of water transpired for every pound of dry-leaf substance.

TABLE 14.—*Amount of water transpired by different forest trees per pound of dry-leaf substance*

	1878	1879	1880
	Pounds	*Pounds*	*Pounds*
Birch	679.87	845.13	918.00
Ash	566.89	983.05	1,018.50
Hornbeam	562.51	759.01	871.70
Beech	472.46	859.50	913.80
Maple (Spitzahorn)	462.87	517.22	611.80
Maple (Bergahorn)	435.77	618.30	703.80
Elm	407.31	755.00	822.80
Oak	283.45	622.21	691.50
Oak (Zerreiche)	253.33	614.22	492.20
Spruce	58.47	206.36	140.20
Scotch pine	58.02	103.72	121.05
Fir	44.02	77.54	93.80
Austrian pine	32.07	99.92	70.05

Thus, during the vegetative period, birch and ash trees transpire for every pound of dried-out leaves from 567 to 1,019 pounds of water—more than do any other forest trees; beeches and maples from 436 to 914 pounds; oaks from 253 to 692 pounds; and conifers, which transpire least, from 32 to 206 pounds. The difference in the amount of transpiration in the different years is explained by the fact that the years 1879 and 1880 had more rain and therefore more water penetrated the soil.

Höhnel estimates that a fully stocked beech stand, 115 years old, consumes from 1,560 to 2,140 tons of water per acre, or 1.15 acre-feet per year. The last means that if the water were spread over an acre it would have a depth of 1.15 feet. If an acre contains 526 trees from 50 to 60 years old, the water consumption is only 1,026 tons per acre, or 0.70 acre-foot; and if it contains 1,620 trees, only 35 years old, the consumption is as low at 321.5 tons per acre, or 0.23 acre-foot. Höhnel expressed the quantities of water that were transpired in 1880 in per cent of the precipitation of that year. He found that elm transpired 43½ per cent, beech 25 per cent, and birch 40 per cent of the precipitation. In 1878 and 1879 the per cent of transpiration was smaller.

Wollny, in observations carried on for six years, determined the amount of water transpired by different species of trees in pots, containing identical amounts and kinds of soil, by measuring the amounts of water which percolated through the pots. He found that spruce transpires, on an average, during the year 37.9 per cent of the annual precipitation and birch 27.8 per cent; but that during the vegetative period the amount transpired by the two species is almost the same, spruce 33 per cent and birch 32.1 per cent.

Ney[31] computed, on the basis of Höhnel's results, the amount transpired during the entire vegetative season by beech as 10.8 inches, spruce 8.3 inches, and pine 2.9 inches; or, for the forest in general, 7.3 inches. This, expressed in per cent of the total precipitation (31.5 inches), would be 23.2. In the case of coniferous trees the amount transpired during the winter must be taken into account, so that the transpiration of pine for the entire year would be 3.1 inches (10.2 per cent of the total precipitation) and for spruce 9.1 inches (28.9 per cent of the total precipitation).

TOTAL AMOUNT OF WATER LOST TO STREAMS

Loss of water to streams through interception by tree crowns and ground cover, by evaporation from the ground, and by transpiration, in a level country with no surface run-off, may be summed up for different kinds of forest, as in Table 15.

TABLE 15.—*Loss of water to streams in forests in level country (annual precipitation 31.5 inches)*

	Interception by forest cover	Evaporation from soil	Transpiration	Total loss	Total loss of annual rainfall
With leaf litter:	*Inches*	*Inches*	*Inches*	*Inches*	*Per cent*
Beech	6.7	1.9	10.8	19.4	61.5
Pine	9.4	2.8	3.1	15.3	48.6
Spruce	12.1	2.6	9.1	23.8	75.6
Average	9.4	2.4	7.7	19.5	61.9
Without leaf litter:					
Beech	4.7	4.7	10.8	20.2	64.1
Pine	6.3	7.6	3.1	17.0	54.0
Spruce	10.5	6.1	9.1	25.7	81.6
Average	7.2	6.1	7.7	21.0	66.7

On the basis of Wollny's and Riesler's experiments Ney has determined the total annual loss of water from field crops through interception of precipitation by the plants, evaporation from the soil, and transpiration to be as shown in Table 16.

TABLE 16.—*Loss in water to streams from field crops*

	Total loss	Annual precipitation (31.5 inches)
	Inches	*Per cent*
Meadow (overflowed)	41.6	132.1
Potato field	13.5	42.9
Grain field	25.3	80.3
Field crops in general	19.4	61.6

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[31] Ney, C. E. Wer Wald und die Quellenbildung. (Forstwissenschaftliches Centralblatt 1901, p. 452.)

On bare soil in level country the only loss is from evaporation from the soil. This amount has been found to be on an average about 50 per cent of the precipitation.

The figures given, which are corroborated by daily practical experience, shows that in a level country a soil covered with vegetation of some kind surrenders to the ground waters a much smaller amount of water than bare soil with no vegetation at all, and a forest, at least a spruce forest, less than field crops. The only vegetative cover which uses up more water than a spruce forest is an overflowed meadow, which can draw upon a supply of water in addition to the precipitation. That any vegetable cover in a level country tends to reduce the amount of water available for stream flow is clearly shown by numerous experiments. In the United States King[32] has demonstrated this for corn. During the growing seasons of 1899 and 1890 the mean height of ground water under corn was lower than that under fallow land. From this he inferred that corn exerts a measurable influence in depressing the height of ground water lying at a depth of over 7 feet below the surface.

Recent experiments in Russia by Ototzky and others, taken with those by German and French investigators, have brought out the fact that in a level country with ground waters not in motion the humidity of the forest soil, which is very great at the surface, rapidly decreases with depth. According to Ebermayer, this desiccating influence extends under spruce stands to 31.5 inches, and, according to Russian investigators, even to from 10 to 13 feet. The forest, like any other vegetable cover, desiccates the layer of soil within which its roots are active, and since the roots of forest trees go to a much greater depth than the roots of cultivated crops, this has led to the conclusion that forest cover absorbs more moisture, and therefore desiccates the soil to a greater depth, than any other vegetal cover.

These investigations, of which those carried on by Professor Henry in the forest of Mondon, near Luneville, France, must be considered the most conclusive, have established with sufficient accuracy that in the forests of a level country in a temperate or cold climate, where the geological strata are homogeneous and horizontal, and the ground water is, therefore, not in motion, and where there is no surface run-off, (1) the water table is lower under the forest than outside during every season of the year, and (2) this depression is more marked in regions with deficient precipitation than where the precipitation is great.

Ototzky's and Henry's experiments can not, however, be generalized for all species and for all level countries of the world, since there are species and level regions where just the reverse is true. Thus, for instance, in level tropical regions, where the heat is intense, and the bare soil, though it may receive large quantities of rain, is subject to great evaporation, the soil under forest cover, in spite of intense transpiration, may contain more moisture than that in the open, especially since transpiration in tropical climates during the period of rest, which occurs in the hot season (equivalent to the winter of the Temperate Zones), is considerably reduced, while evaporation, which follows physical laws, is especially intense at that time.

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[32] King, F. H. Observations and experiments on the fluctuations in the level and rate of movement of ground water. (U. S.—Weather bureau. Bulletin 5, 1892, p. 32.)

B. Ribbentrop[33] reports that wells from 6 to 10 feet deep, dug within the forest plantations in the suburbs of Madras, near Trichinopoli, British India, contain water during the hottest season, while neighboring wells, 15 feet deep, outside of the forest, and rivers in the vicinity, are entirely dry during the hot months. This is due to the enormous evaporation from the bare soil during the hot months, evaporation which is much greater than the transpiration from the forest cover.

It is also true, as Ney has shown, that, from the consumption of water by different forest trees, it may be inferred that in a level country the cutting away of such forests as beech or spruce may even lead to an increase in ground waters. The cutting away of pine forests in a level country would, however, be injurious to ground waters unless the soil should remain entirely bare, for any other vegetation which would take the place of pine would consume a larger amount of water and, therefore, tend to lower the ground water to a greater extent than the pine forests.

The lowering effect on ground waters of the forest is well known from practical experience. The afforestation of the swamp lands of southern France, called the Landes, with maritime pine, brought about a lowering of the water table. In Italy the water table in swampy regions in Europe the drainage ditches, which before afforestation were always full of water, after planting became entirely dry.

As a net result of all these experiments in different parts of the world, it must be admitted that a difference exists between the hydrophysical influence of the forest in the plains and that of forests in the mountains and hills. In the plains the forest, because of its desiccating effect upon the soil:

(1) Constitutes an effective means of draining and drying up swampy lands, the breeding places of malaria and swamp fevers. The reforestation of the Landes, Sologne, the Pontine marshes, and a hundred other examples prove this.

(2) It draws moisture from a greater depth than does any other plant organism, thus affecting the unutilized water of the lower horizontal strata by bringing it again into the general circulation of water in the atmosphere, and making it available for vegetation.

(3) While it lowers to some extent the subterranean water level, it has no injurious effect upon springs, since these are practically lacking in the level countries with horizontal geological strata where its lowering influence has been chiefly noted.

(4) It refreshes the air above it and increases the condensation of moisture carried by the winds, thus increasing the frequency of rains during the vegetative season.

EFFECT OF FOREST IN MOUNTAINOUS REGIONS

INTERCEPTION, EVAPORATION, AND TRANSPIRATION

In mountainous regions, as already shown, the amount of precipitation increases within certain limits with elevation. The denser the forest cover, the greater is this increase. Forests in the mountains receive more precipitation than forests at lower altitudes in the same region.

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[33] Ribbentrop, B. Influence of forests on the climatic conditions and fertility of a country. (In his Forestry in British India, 1900, pp. 39–59.)

The loss of precipitation through interception (i) by tree crowns and humus in mountainous regions, while it has never been measured accurately, is accepted to be less than in level regions, first, because in the mountains precipitation more often falls in heavy showers, and second, because a larger part of it is in the form of snow.

In mountain forests the loss through direct evaporation (e) from the soil is considerably less than in forests of a level country, because of the lower temperatures at higher altitudes.

The amount of water transpired (t) by a forest in the mountains is also less, for the vegetative period is shorter, the temperature lower, and there is, in consequence, less growth per unit of area. This is well illustrated by the variation in the amount and weight of leaves produced by the same species at different altitudes. At an elevation of 450 feet, 1,000 beech leaves have an aggregate surface of 36.7 square feet, but at an elevation of 4,500 feet this falls to 9.8 square feet. Not only the surface and weight of the same number of leaves decrease with increase in altitude, but the ash content decreases as well. At a height of 450 feet, the ash content of beech leaves is 9.91 per cent, and of fir needles 10.19 per cent. At an elevation of 3,500 feet, that of beech is 4.03 and of fir 3.58 per cent.

Thus in mountain forests everything tends to reduce loss of precipitation, through interception, evaporation, and transpiration, to a minimum, and, consequently, to increase the amount of water available stream flow.

Observations carried on in forests over a broken topography, where the geological strata are not horizontal, and the ground waters therefore in motion, and where there is a surface run-off, have failed to establish any lowering of the water table under the forest. On the contrary, Hartmann,[84] hydraulic engineer of the State of Bavaria, who carried on these investigations in cooperation with the Bavarian Forest Service at the initiative of the International Association of Forest Experiment Stations, found that the water table at Mindelheim (altitude 2,000 feet) was nearer the surface in the forests than outside.

SURFACE RUN-OFF CONVERTED TO SEEPAGE

In the mountains the greatest source of loss of precipitation is through surface run-off (r), and the most important influence which a forest cover has is in reducing this.

A German investigator of high standing (Ney) estimates the amount of water which the forest cover saves to the soil by reducing the surface run-off and changing it to underground seepage to be as follows: For forests at low altitudes where the rains are not heavy and the soil is less subject to freezing, 20 per cent; for forests of moderate altitudes, 35 per cent; and for mountain forests, 50 per cent of the precipitation.

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[84] Ebermayer, E., and Hartmann, O. Untersuchungen über den Einfluss des Waldes auf den Grundwässerstand. Munich, 1904.

Measurements of surface run-off made in 1860 by Jeandel, Cantegril, and Bellot[36] in the Vosges, show that the surface run-off from the wooded slopes is only about half as much as that from deforested slopes, while, from the former, the underground seepage is greater and the flow of the streams more regular.

Such an authority as Huffel[36] states that under ordinary conditions of rainfall there is practically no surface run-off from wooded watersheds having an abundant leaf litter.

The saving of precipitation effected in this way by the forest is more than sufficient to offset whatever loss may be sustained through transpiration or interception by tree crowns. This is clearly brought out by the following facts: The entire loss of water from forested areas at moderate altitudes, even on the steepest slopes, is about equal to that from forest in level country.[37] Ney places this at 19.4 inches or 61.5 per cent of the precipitation (31.5 inches). Cultivated fields on similar slopes have been computed to lose, through interception by vegetable cover, evaporation from the soil, transportation, and surface run-off, 24.9 inches, or 79 per cent of the precipitation, and bare surfaces 27.2 inches, or 86.4 per cent. The higher the altitude, the steeper the slope, the heavier the rainfall, and the greater the precipitation, the more marked will be the difference. This holds true, not only for such species of trees as beech or pine, the entire loss of water from which is less than that from cultivated fields, but also for spruce. Although in a level country a spruce forest consumes more water than do cultivated fields, at high elevations, where the precipitation is from 43 to 47 inches, it consumes only 9.2 inches, or 21.5 per cent of the total precipitation, less than open fields and nearly 15.7 inches or 34 per cent less than bare surfaces.

The ability of the forest to check surface run-off is greatest when the ground beneath is covered with an unbroken leaf litter. A forest without leaf litter, on slopes at moderate altitudes, has little effect in checking run-off. The entire loss of precipitation from such a forest was found to be 26.9 inches, while that from bare surface in the same situation was 27.2 inches. Hence, for a forest to exercise its most beneficial effect upon run-off, it must not be burned over, grazed, or otherwise interfered with in its normal function.

That a normal forest in the mountains saves more water for stream flow than any other vegetal cover or any bare surface is shown also by the abundance of springs in mountain forests.

This difference in the hydrological influence of the forest in level country and in the mountains makes clear how unfounded is the contention occasionally expressed that if the forests are to control stream flow it is necessary to keep them not only on the headwaters of the stream but also on their lower levels, since the latter form by far the largest part of the drainage basin. As carefully conducted experiments have shown, the presence of forests at low levels, especially spruce, may impoverish the ground waters instead of enriching them. At best the influence would be the same of that of agricultural soil kept in good tillage. A forest in the mountains, on the other hand, actually conveys more water to the ground than does any other vegetal cover. The greatest influence of a forest upon stream flow, therefore, is at high altitudes, where precipitation is heaviest, slopes steepest, and erosion easiest. Even if good agriculture, as sometimes claimed, could have there the same effect upon erosion and absorption of water as forest cover, which it has not, the fact would be of no practical value, since agriculture at high altitudes is, as a rule, impracticable.

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[36] Jeandel, F., Cantegril and Bellot. Études expérimentales sur les inondations. Paris, 1862.

[36] Huffel, G. Études expérimentales sur les inondations. Paris et Nancy, 1862.

[37] Ney, C. E. Der Wald und die Quellen. Tübingen, 1893.

Reduction of surface run-off means both an increase of underground seepage and prevention of erosion, two important factors in the regulation of stream flow. The action of mountain forests in protecting the soil against erosion and in increasing underground seepage at the expense of surface run-off is the result of their ability to lessen the severity of rainfall, to retard the melting of snow, to offer mechanical obstacles to surface run-off, to hold the soil together, to keep it in a permeable state, to increase its volume by constantly adding new soil, and to absorb large quantities of water by its leaf litter.

Severity of rainfall checked.—The amount of water which filters into the ground depends, for one thing, upon the length of time the water remains in contact with the soil. For slopes of the same gradient this, in turn, depends upon the duration of the rain or on the time the snow takes to melt. Imbeaux [88] found, for deforested or poorly forested watersheds near Mirabeau, that during three exceptional rainfalls the surface run-off from slopes of the same gradient constituted in one case 33 per cent, in another 39 per cent, and in a third 42 per cent of the precipitation, while during less heavy rains this per cent fell to 22 and in light rains to 18. Other figures obtained at the confluence of the Durance with the River Rhone were close to those obtained at Mirabeau but somewhat smaller. For the Danube, near Vienna, Lauda, the Central Hydrographic Bureau, using the same method, found that for the period between July 28 and August 14, 1897, the surface run-off formed 42 per cent of the precipitation.

The forest modifies both the severity and the duration of the rainfall. By its foliage and branches it breaks the force of the rain, so that the water reaches the soil without violence and at the same time prolongs its duration. After a storm water continues to drip from the leaves and twigs for one or two hours. The water in the forest, therefore, falls more quietly and for a longer time and has thus a better chance to be absorbed by the soil.

Melting of snow retarded.—The rapid melting of the snow in the spring, especially when the ground is frozen or is saturated with water, favors surface run-off and lessens seepage. In this country the systematic measurement of snow in the mountains has but recently been begun by the Weather Bureau in cooperation with other bureaus, and it will be several years before definite results are obtained.[89] Such measurements, however, have been made in other countries, and the influence of the forest upon the melting of snow has been thoroughly determined by experiment, especially in Russia, where snow forms a large portion of the precipitation and affects most vitally the flow of streams.

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[88] Imbeaux, E. Essai programme d'hydrologie. (Zeitschrift für Gewässerkunde, 1898–1899, v. 1, pp. 68–91, 225–278; v. 2, pp. 220–248, 257–274.)

[89] U. S.—Department of Agriculture—Weather Bureau. Instructions No. 76.

At the Imperial Agronomic Institute at Moscow measurements on the amount of snow that reaches the ground in the forest have been carried on for five years, both by means of rain gauges and directly by measuring the snow cover in the forest before its melting. These measurements show very clearly that the species, density, and age of the forest have a direct influence upon the amount of snowfall that reaches the ground. Thus, while in a birch stand between 70 and 75 years old only from 4 to 5 per cent of the total snowfall is prevented from reaching the ground, in dense spruce stands the tree crowns retain from 50 to 55 per cent. In other words, only about half as much snow reaches the ground in a dense spruce forest as in the open. This is brought out in Table 17.

TABLE 17.—*Interceptive influence of forests on snowfall*

	Number of areas examined	Number of measurements of snow depth	Number of snow samples weighed	Thickness of snow			Water equivalent of snow depth	Amount of water per acre
				Minimum	Maximum	Average		
				Inches	*Inches*	*Inches*	*Inches*	*Cubic feet*
1. Young plantations (2 to 4 years old) and small clearings within the forest	20	259	7	15.4	26.8	21.9	5.1	18,420
2. Birch forest (35 to 75 years old)	11	377	27	18.9	26.8	22.2	5.0	18,290
3. Oak forest (25 to 90 years old)	2	62	8	19.7	27.2	23.5	5.6	20,148
4. Pine forests	32	887	56	11.4	19.7	15.5	3.1	11,255
Young (25 to 35 years old)	25	662	43	11.4	19.7	15.2	3.1	10,417
Old (60 to 90 years old)	7	225	13	11.8	19.3	16.4	3.2	11,497
5. Spruce forest (25 to 35 years old)	21	460	29	6.7	13.8	9.7	2.1	7,711
6. Pine forest with admixture of birch (65 to 75 years old)	4	6	3	14.2	22.8	20.0	4.4	15,753
Pine forest with admixture of larch (25 to 35 years old)	3	74	2	11.4	16.5	15.2	3.1	11,280
Pine forest with admixture of spruce (35 years old)	5	157	9	8.7	15.7	12.9	2.9	10,391
7. Spruce forest with admixture of larch	3	57	2	8.3	21.7	14.1	3.1	11,103
8. Cultivated field	1	332	8	5.1	22.4	13.0	3.1	11,261

Thus an acre of broadleaf forest (birch 35 to 75 years old and oak 25 to 90 years old) will contain per acre about 41 per cent more snow water than a pure pine forest (20 to 90 years old); 60 per cent more than a pure spruce forest; or an average of about 50 per cent more than coniferous forests in general. The table shows also that the age of the stand has an important influence upon the amount of snow on the ground. Thus young pine stands contain from 9 to 10 per cent more snow than older pine stands (60 to 90 years old). The important fact which these figures show, however, is that young forests, deciduous forests, and small openings within the forest collect nearly twice as much snow as open fields, while dense, pure spruce forests contain less than open fields.

Upon the comparative loss of snow through drifting or evaporation from forested and from unforested areas there exists comparatively little data. This is due chiefly to the great difficulty of making satisfactory measurements on the wind-blown and constantly shifting snow in the open. Such meteological observations and empirical data as do exist, however, agree in showing that the loss of snow in the forest during thaws in the winter and from other causes is much less than that outside. This is due, as in the case of aqueous precipitation, to the protection afforded by the forest cover from the direct rays of the sun and from radiation, to the lesser circulation of the forest air, and to the narrower range of temperature inside the forest than outside. Because of this protection from the sun and wind and also because of the partial retention of the spring rains by the forest cover the melting of snow in the forest continues for three, four, and five weeks longer than in the open.

The influence of forests in retarding the melting of snow has been demonstrated with especial precision in a 10 years' series of observations carried on at the Imperial Agronomic Institute at Moscow. These show that the period of snow melting lasts within the forests from 26 (1904) to 57 (1902) days, while snow in the open disappears within 6 or 7 days. Thus in 1908 the melting of snow, which began April 12, lasted in the forest until May 15 (34 days), but in the fields, pastures, and all other open places surrounding the institute only until April 22 (11 days), while in the more exposed fields the snow had all disappeared as early as April 18, 7 days after it had begun to melt. The retention of snow in the forest until May 15 was in spite of the fact that after April 22 there were frequent warm rains.

The rapidity with which snow melts in the forest varies with the species and with the density, age, and location of the stand. This variation has been found to hold true from year to year, irrespective of the weather at the time of melting. The snow disappears first of all from clearings in the forest, simultaneously with its disappearance from open fields. Next it disappears from young forest plantations, in which the tree tops have not yet begun to touch each other; then from thin oak forests on southerly slopes and old, open pine forests; then from dense stands of birch on northerly slopes; later from pine; and last of all from spruce. Thus in 1908 at the Imperial Agronomic Institute the ground in field and forest became entirely free of snow on the following dates:

In fields, clearings, and open places	April 22.
In young, open stands	April 24.
In old, open stands on south slopes	April 26.
In birch stands	April 29.
In pine stands	May 6.
In spruce stands	May 15.

Thus, while compared with deciduous stands, coniferous forests, and especially pure dense spruce, prevent large accumulations of snow, their effect in retarding its melting, especially in the case of spruce, is much greater, and for this reason they are more efficient in reducing the height of spring freshets.

In an ordinary forest region the water in the streams in the spring is derived from three sources: (1) The snow water that runs off from fields and clearings; (2) the surface run-off from forest soil, however slight; and (3) one, one and one-half, or two months later, after all the snow is melted, the underground water. With the destruction of the forest the ground water is greatly decreased, there is no longer the retarded surface run-off from forest soil, and nearly all the snow water runs off at once as surface water from the fields and cleared land.

In cultivated fields and clearings in the north the ground is still frozen when the snow melts. This, together with the rapid melting of the snow in the open, causes the water soon to run off, even from gentle slopes, in great quantities, as though from the roof of a building. Freezing of the ground in fields and clearings is due chiefly to unimpeded radiation in the fall and to the blowing away of the protective cover of snow in the winter. Cultivated ground freezes especialy deep during the winter if saturated with rain water at the time of the first fall frost. Surface run-off from open fields is further increased when thaws during the winter coat the ground under the snow with an icy sheet, over which the snow waters run off in the spring without penetrating the ground.

In the forest, on the other hand, the soil is warmer than in the open. It is protected from radiation by trees. It is further protected by the leaf litter, a poor conductor of heat, which both prevents its cooling off and protects it from freezing in winter, and in the processes of fermentation and decay contributes the heat which these evolve. The relatively even cover of snow on the ground protects it still further. Under this triple protection the forest soil either does not freeze at all or freezes much later in the winter and to a much less depth than in open places. Moreover, it thaws out in the spring while still under its cover of snow. The slow melting of snow in the forest, together with the unfrozen, or only slightly frozen, condition of the ground beneath, permits a much greater percolation there than in the open. This water-holding capacity of the northern forest is more marked in coniferous stands, especially in spruce.

Closely connected with the relatively high temperature of the forest soil is another important fact which is often entirely overlooked. If the soil of watersheds remains soft and unfrozen, the ground water which feeds the streams continues to flow throughout the winter, thus keeping up the normal winter water stages in the streams under the ice. If, however, the flow of underground water ceases during the winter, the water accumulates in the ground, small streams freeze to the bottom, and the water stage of the river falls. In spring the ground water which has accumulated behind the icy dams thus formed at the bottoms of slopes bordering the streams enters the rivers in large quantities. For the regimen of rivers, therefore, the importance of forest cover on slopes bordering springs, creeks, and small streams, which are fed by underground waters, is especially great.

Surface run-off obstructed.—The forest floor, penetrated by a network of roots and covered by branches and stumps, offers many obstructions to the surface run-off and so permits the water to sink into the ground. Percolation is made still easier by the presence of deep channels in the soil, left by the decay of large roots.

The porosity or permeability of the soil has a great influence on the amount of surface run-off. The influence of the forest, therefore, will vary with the character of the soil on which it grows. On heavy clay or other impermeable soils the crowns of trees, which break the violence of the rainfall, together with a surface mulch of leaves and twigs, prevent the soil from becoming compact and allow it to retain its granular structure, thus making it more permeable to water. On a soil very permeable to water, such as sand, the influence of the forest in decreasing surface run-off may be very insignificant, consisting chiefly in preventing the soil from being washed away.

An unbroken forest soil cover of half decomposed leaf mulch and humus aids greatly in retarding surface run-off and forcing it to penetrate into the ground. Its importance in this respect is made clear by the following facts: The leaf mulch on an acre of virgin beech forest weighs, when air-dried, about 8,818 pounds; in a pine forest, 15,873 pounds; and in a spruce forest, 12,346 pounds. If the specific gravity of the air-dry leaf litter be only 0.5, then the dry substance of the leaf mulch if evenly distributed over an acre would cover it in a beech forest to a depth of only 0.08 inch, in a pine forest to 0.14 inch, and in a spruce forest to 0.11 inch. In nature, however, this amount of leaf litter covers the ground in beech and pine forests to a depth of 3.1 inches, and in a spruce forest to a depth of 3.9 inches, which gives an idea of the space within the leaf litter and of the volume of water it may accommodate.

Hüffel found that a forest with leaf litter, after a rainfall of from 2.4 to 2.8 inches, did not give off, even on the steepest slopes, a drop of water in the form of surface run-off. If water does not run off from such stands it comes from the precipitation which falls on an area deprived of its forest cover—for instance, a road.[40]

To determine precisely the actual effect of different kinds of forest soil in retaining the water which they receive as rain or melting snow, Prof. E. Henry[41] conducted a series of experiments with typical soils from spruce and beech forests. Taking the greatest care to preserve the natural arrangement and solidity of the soil, a number of samples were removed, thoroughly saturated by plunging into water for several days, drained of the excess moisture, and weighed. After being thoroughly dried at a temperature of 100° C. (212° F.) the samples were reweighed, and the weight of water held by the saturated soil thus determined. From the average of all the weighings it was found that the spruce-needle humus contained, when saturated, 4.15 times its own weight in water, while the beech-leaf humus contained 5.38 times its own weight. When simply air-dried, which is, of course, the case in nature, beech-leaf humus was found still to absorb 4.41 times its weight, while air-dried spruce humus took up about 3.38 times its weight.

To ascertain the actual amount of water absorbed and retained per given unit of area by spruce and beech humus, the average weight of oven-dried (100° C.) humus per 2½ acres was determined. Allowing 15 per cent for excess moisture content of air-dried over oven-dried humus, the air-dried spruce and beech humus were found to have a retentive capacity of approximately 46.44 and 22.2 tons of water per acre, respectively. This amounts in volume to 1,510 cubic feet per acre for spruce and 712 cubic feet for beech humus, equivalent to a rainfall of 0.41 inch and 0.2 inch, respectively.

The depth of soil has a bearing upon the amount of water which it can retain. No matter what its character may be, a thin soil can not retain much water. The forest, however, tends to increase the volume of soil, and thus creates greater reservoirs for water. It does this in two ways: (1) From above, by the addition of leaves and twigs, which, when decayed, become a constituent part of the soil; and (2) from below, by inducing disintegration of decomposition of the underlying rock. The forest, by constantly increasing the depth of the soil, lessens the likelihood of it being washed away and enables it to remain where it was formed. The addition of organic matter to the soil increases its water-holding capacity. The tree roots at the same time enter the narrow fissures of the rock, which they widen, thus producing many new openings into which the water may sink.

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[40] Ney, C. E. Der Wald und die Quellen. Tübingen, 1893.

[41] Henry, E. Influence de la couverture morte sur l'humidité du sol forestier. (Annales de la science agronomique, 1901, tome 2, 182–196.)

During the vegetative season the demand of the forest upon the water stored in the ground is very great. In summer the forest, like other crops, consumes more water than it receives in the form of precipitation. At the end of the vegetative season, therefore, the level of the underground water is low. As a result, the forest soil can absorb large quantities of water during the period of vegetative rest, when there is an excess of water on the ground, either from heavy rains or from the melting of snow. The forest soil, therefore, forms a reservoir whose capacity is greatest when the excess of water on the ground and the danger of floods is greatest. The water stored in the time of rest is used by vegetation and for the flow of streams later on when there is usually a deficiency of precipitation.

SUMMARY OF THE EFFECTS OF FORESTS IN CONSERVING PRECIPITATION

(1) The hydrological rôle of forests in level countries differs from that of forests in hilly or mountainous regions.

(2) In level country, where there is no surface run-off, forests, in common with other vegetation, act as drainers of the soil; hence their importance in draining marshy land and improving hygienic conditions. In such country their effect upon springs is unimportant.

(3) In hilly and mountainous country forests are conservers of water for stream flow. Even on the steepest slopes they create conditions with regard to surface run-off such as obtain in a level country. Irrespective of species, they save a greater amount of precipitation for stream flow than does any other vegetable cover similarly situated. They increase underground storage of water to a larger extent than do any other vegetable cover or bare surfaces. The steeper the slope the less permeable the soil, and the heavier the precipitation the greater is this effect.

(4) In the mountains, the forests, by breaking the violence of rain, retarding the melting of snow, increasing the absorptive capacity of the soil cover, preventing erosion, and checking surface run-off in general, increase underground seepage, and so tend to maintain a steady flow of water in streams.

FORESTS AND EROSION

One far-reaching influence of the forest upon stream flow lies in its ability to protect the soil from washing. Wherever the topography is at all rough erosion of the soil is a factor to be dealt with. The extent to which soil is eroded depends upon the climate, steepness of the ground, the character of the coil, the geological formation of the region, and the surface cover. When the slopes are steep, the soils and the underlying rock friable, the rains torrential, and the surface bare of vegetation, erosion by surface run-off reaches colossal proportions. In such regions thousands of acres of fertile soil are destroyed each year and millions of cubic feet of silt deposited in the bottom of rivers to form bars and shoals which change the regimen of the streams and obstruct navigation.

Erosion on cleared slopes above the headwaters of streams, where agriculture is impracticable, may be prevented by sodding, by a growth of shrubs, by engineering work such as log or rock dams in deep gullies, or by covering the surface with straw, leaves, and brush. The most permanent, effective, and cheapest protection against erosion, however, is a forest cover. Grass, while effective in preventing erosion, does not diminish the surface run-off and serves no other useful purpose. A surface blanket of straw, leaves, and brush is only a palliative, and must eventually be replaced by some permanent cover. Engineering work is, as a rule, very expensive, and alone will not fully accomplish the purpose sought. Where the soil has been entirely washed away, however, engineering work of some sort is necessary before any vegetable cover can be started.

The forest is the most effective agent for protecting the soil from erosion because (1) the resistance of the soil to erosive action is increased by the roots of the trees, which hold the soil firmly in place, and (2) at the same time the erosive force of the run-off is itself reduced, because the rate of its flow is checked and its distribution over the surface equalized.

France furnishes a good example of the effect of forest cover upon erosion and stream flow. There some 800,000 acres of farm land had been ruined or seriously injured as a result of clearing about the headwaters of streams, and the population of 18 departments was reduced to poverty and forced to emigrate. In 1860 forest planting was begun on the headwaters of the streams. Already 163 torrents have been entirely controlled by this means, and 624 more are beginning to show the effects of forests on their headwaters. Thirty-one of the torrents now entirely controlled were a half century ago considered hopelessly bad. The foremost French engineers, after many experiments, have come to the final conclusion that forest cover is one of the most effective means for checking erosion and that the best place to control stream flow is at the headwaters of the streams. Examples of reforestation of mountains for the control of torrents are to be found not only in the French Alps but also in the Swiss Alps and in Tyrol.

Erosion has a bearing on the height of flood water in the rivers, since the sediment carried by the rivers and the coarser detritus brought down by mountain streams often increase stream volume to such an extent that the height of the water is raised far beyond the point it would reach if it came free of detritus and sediment. When the channel of a stream has become filled with waste material even a slight rainfall will cause a flood, while, if the channel were deep, it would have no perceptible effect upon the height of water in the stream. The filling of mountain streams with waste not only increases the frequency of floods but causes the streams to assume the character of torrents. A channel filled entirely or partially with foreign material can not hold large quantities of water, while the denuded slopes deliver the storm water almost as fast as it falls.

How great may be the volume of detritus carried by a given volume of water is shown by Demontzey,[42] who computed that one mountain torrent brought down in 85,020 cubic yards of water 221,052 cubic yards of detritus, or more than two and a half times its own volume.

L. C. Glenn[43] ascribes the change in regimen of many of the mountain streams in the southern Appalachian to the denudation of the steep mountain slopes and the consequent erosion. He finds conclusive evidence of increased erosion, the result of clearing on the mountain stream basins since 1885, in the character of the flood-plain deposits within recent years. When floods are small or gentle the flood-plain deposits consist of fine alluvium. When the floods are great and violent the deposits consist of coarse sand, cobbles, and bowlders. In the past the flood-plain deposits of such southern rivers as the Watauga, the Doe, the Nolichucky, the French Broad, the Catawba, and the Yadkin were built of fine sandy loam or clay. In the last decade, however, the deposits have grown coarser, which points to an increase both in the height and in violence of floods.

In mountainous regions where a thin soil covered with forest is underlaid with hard rock, such as limestone, or with unfertile formations, such as chalk, destruction of the forest may often result in the complete desolation of the region. As long as the soil, formed during centuries by the disintegration of the rock and the accumulation of humus, is held together by the roots of trees, some ground waters may accumulate within it, or even small springs may be found. As soon, however, as the forest is removed the thin soil is washed, even from gentle slopes, and nothing remains but bare rock. Examples of this kind are common all over the world and may be found even in this country, in spite of the fact that here destruction of the forests is comparatively recent, and consequently erosion has not progressed as far in some portions of the Old World. There, as in Karst, portions of Greece, Palestine, and the mountainous provinces of southern France and Italy, the evils of forest destruction and subsequent erosion are strikingly evident.

In Karst deforestation has practically converted the region into a desert. The burning sun now strikes the naked rocks, from which the atmosphere is heated by radiation, while the rain is lost in the rock fissures without benefit to vegetation. For many square miles the country is one of drought.

In the United States the effect of destruction of forest cover upon erosion is most impressively shown by the conditions prevailing in the Ducktown copper region, Tennessee. Smelters started about 16 years ago near Ducktown have killed, by sulphuric fumes, all vegetation in their immediate vicinity. The slopes are now bare and are being rapidly eroded. On Potato Creek this eroded material is accumulating at the rate of a foot or more each year and has buried telephone poles almost to their cross arms. On Ocoee River each flood deposits large quantities of sand and periodically dams the river. The country for several miles has become a barren waste.

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[42] Demontzey, P. Traité pratique du reboisement et du gazonnement des montagnes. Paris, 1882.

[43] Glenn, L. C. Denudation and erosion in the southern Appalachian region and the Monongahela Basin. Washington, D. C., 1911. (U. S. Geological Survey. Professional Paper 72.)

Of all vegetable covers, forests are most efficient in preventing the slopes from eroding and the beds of streams from filling with silt. Even on very permeable soils, where their effect upon the underground storage of water may be of secondary importance, they are necessary as protection against erosion.

PART II.—RESULTS BY THE HYDROMETRIC METHOD

Reliability of Available Records of Stream Measurements

Measurements of the flow of waters in streams from forested and unforested watersheds would theoretically be the best check upon the conclusions obtained by the physical method. Actual measurements of stream flow, however, have not lead to such conclusive results as have the data secured by the physical method; nevertheless, the consensus of opinion among the leading authorities in engineering and forestry the world over is that the forest exercises a potent influence in the regulation of stream flow. It is true that there is a very considerable divergence of opinion on the extent of this influence. Close study, however, traces this to the complexity of the problem and the failure to give due weight to the factors involved, as well as to the needless confusion arising from the introduction of factors which have no bearing on the subject.

While in many countries observations on the behavior of streams date back a number of years, most of them suffer from lack of exact measurements of stream discharge over a period of years long enough to neutralize exceptional conditions, and also from lack of accurate records of the condition of the drainage basin during the same period.

In this country there are about 287 rivers which are classed as navigable. Of these scarcely 25 per cent have any kind of coextensive records of precipitation and stream measurements covering periods of more than 15 years. In Europe records of stream measurements for some rivers, like the Seine, at Paris, have been kept since 1732; for the Elbe, near the town of Magdeburg, since 1728; for the Rhine, since 1770. But these measurements also are not of such a character as to enable one to draw accurate conclusions with regard to the effect of forests upon stream flow. Even in Germany there are not more than two or three rivers for which any records of scientific value are available.

With the exception of a carefully planned experiment by the Swiss Government and a similar experiment started in the Rocky Mountains by the Forest Service, no thoroughly accurate studies of this problem have been made anywhere. In practically none of the American investigations and in very few of the European stream-flow studies have accurate records existed of the condition of the cover on the catchment basins, though in some cases the changes in the cover are roughly referred to for the period under investigation. The mere statement that lumbering has been carried on in a given watershed, while in another watershed no logging has been done, is not a sufficient proof that the beneficial influence of the forest cover on the former has been impaired, while on the other it has not. A logged-over area may contain young reproduction, the effect of which upon the run-off may be just as favorable as virgin forest. On the other hand, a virgin forest, if repeatedly burned or grazed and thus deprived of its leaf litter, may cease to exercise its normal beneficial influence upon the surface run-off. Thus in discussing the relation between precipitation and forest cover the statement has recently been made that in New England, where logging began early in the history of the United States, the average precipitation showed a slight decrease during a certain period (since 1836 up to a few years ago). From this statement it was sought to convey the inference that forest destruction and precipitation have no relation to each other. As a matter of fact, New England alone, of all sections in the United States, has during this period actually been gaining in the area under forest cover.

It is a matter of common observation and knowledge to anyone who travels through New England that many abandoned fields are going back to young, thrifty stands of forest, and actual statistics show a perceptible increase in the forest area of such States as New Hampshire and Vermont. In addition there has been, especially in recent years, a marked decrease in the use of woodland for the pasturage of stock in this part of the country. How misleading are conclusions based on the mere fact that logging has been carried on in certain watersheds is indicated by the conditions existing through the Southwest, especially in southern California. There on the lower edges of the forest a constant struggle is going on between it and the chaparral. Any setback to the commerrial forest, such as destructive lumbering of fire, gives at once an advantage to the chaparral growth which permits it to occupy the place of the other Though the commercial forest is reduced in area, this may have no visible effect upon stream flow, provided the chaparral takes its place, since the latter may have a similar influence on the surface run-off. It is not enough to show in any given case that the forest area has been reduced; it must be shown that the forest has not been replaced by some cover, natural or artificial, which affords a similar protection to the soil.

Deductions made from deficient data secured in limited regions have often been generalized as applying to all rivers, climates, and conditions. In order to bring out the true relation between surface cover and stream flow the conditions must be studied separately for each stream. The effect of the forest on stream flow is different in different climates. It varies with the abundance, character, and distribution of the precipitation and with temperature. In regions with severe winters, abundant snowfall, and sudden springs, all other conditions being equal, the effect is greater than in humid climates with prolonged, drizzling rains.

The effect of the forest varies further with the geological formation, topography, and size of the watershed, as well as with the depth and character of the soil. On steep, impermeable soils the effect of the forest is greatest; on deep sandy soils it may be insignificant In some basins the geologic formation and the dip of the strata are such that as much as 10 per cent of the precipitation is allowed to escape by deep underground passages and so entirely lost, at least to the given drainage basin.

The character of the stream and its tributaries, the slope or gradient of the stream, the presence of falls and rapids, the section of the stream, the arrangement of the tributaries, and the presence of natural storage reservoirs all have an important bearing upon the character of the flow in the stream. They may also obscure or increase the effect of forest cover. The artificial use of streams for irrigation or for water supply may again obscure the true effect of the forest on the regulation of its flow.

Observations of the factors affecting stream flow, like precipitation, stream discharge, and forest condition, in order to yield conclusive results, must be carried on for long periods of time, covering not only a few years of extreme conditions but also embracing periods of climatic fluctuations.

The height of the water in a river may rise or fall with a change in the character of the bed, yet the amount of the water discharged by the river may remain the same. This change, for instance, may be caused by silting of river beds. In order to obtain reliable data as to the discharge of rivers, it is therefore necessary to measure not only the height of the water but also the rapidity of the flow, since both of these affect the discharge. This, however, has been done on very few rivers either here or abroad.

Most of the studies of stream flow so far made have been confined to large river basins of many thousand square miles. On such there exist many conditions of soil, topography, and vegetative cover, which counteract each other and obscure the relation that may exist between the behavior of the stream and any one of these factors. Recently the International Association of Forest Experiment Stations abroad has realized that the relation of soil cover to stream flow can not be satisfactorily studied from observations on rivers with large drainage basins, and the central forest experiment station at Zurich, Switzerland, is now carrying on intensive observations on two drainage basins, one with an area of 140 acres and the other of 175 acres. For the same reason for Forest Service, in its intensive study of the relation of forest to stream flow, now being carried on in the Rocky Mountains on the Rio Grande National Forest, has selected two watersheds of 212.3 and 222.7 acres, respectively.

A great many observations have been carried on on the lower portions of large rivers. These are misleading, since they are the result of the diverse conditions prevailing on the various tributaries.

The method of computing the results of stream gaugings and precipitation has a most important bearing upon the problem. By averaging the records of stream gaugings and precipitation for two periods, for which the regimen of the stream is compared, it is possible entirely to obscure the effect which forests might have had on the flow of water. By working up the data separately for each storm it may be possible to show much more fluctuation in one period than in the other. Thus, Prof. Willis Moore, Chief of the United States Weather Bureau, by computing the average annual river stage of the Ohio River at Cincinnati for two periods between 1871–1889 and 1890–1908, as well as the average precipitation for the two periods, found that both the flow of the Ohio River and the precipitation over its watershed did not vary perceptibly in the two periods under comparison. On the other hand, Mr. M. O. Leighton, chief hydrographer of the United States Geological Survey, by comparing the annual precipitation and the number of days in each year that the gauge registered 20 feet and above on the Ohio River at Wheeling, W. Va., clearly showed a change in the behavior of the river during the period between 1896–1907 as compared with the period 1885–1895.

The importance of all these factors has been recognized only within comparatively recent years, and scientific methods of studying the relation of forest to stream flow, even abroad, have not been followed for very long. No thorough observations extend very far back, therefore, on any of the European rivers, and less so on our own rivers. Any attempt to base conclusions upon inexact observations of stream flow made before the present scientific methods were introduced leads only to groundless speculation and confusion. A striking example of this is given by the Tiber, with the exception of the Nile perhaps, the most historic of rivers. It has so far proved impossible to ascertain whether the floods of the Tiber have increased or diminished in the course of centuries, owing to the fact that the incomplete records lend themselves to conflicting conclusions. Under these circumstances it is clear that the American records, as well as the European, can show at most only tendencies, though these tendencies may be so marked as to justify important inferences.

Records of American Rivers

A general study made by the United States Geological Survey and the Forest Service of the changes which have taken place in the flow of rivers in the United States, during the time for which records have been kept, revealed the fact that in many streams, particularly in those which rise in the eastern mountains, there has been during the past 20 or more years a marked and steady increase in the fluctuation of all the river stages and in the duration of high and low waters. Of especial importance is the work of M. O. Leighton,[44] chief hydrographer of the United States Geological Survey, whose report to the National Conservation Commission is not only the first systematic attempt at a broad and comprehensive review of river discharge records in the United States, but also marks a departure in the method of computing the river discharge records.

It has already been pointed out that a comparison of average river stages for two periods can not prove or disprove the effect of forest cover upon stream flow. Professor Moore's method of comparing the average annual discharge and precipitation of the Ohio River in each of the 19-year periods for which records are available simply proves that the average annual discharge of the Ohio River in each of the periods has been the same. Since practically as much rain fell in the one period as in the other it is no cause for surprise that the stream's average was the same for both. It has been lost sight of that the average flow in one of the periods might be made up of comparatively uniform stages, and in the other of many short and sharp floods with intervening low stages. It is as unsafe to rely on averages to show changes in a stream's regimen as it would be to rely on accidents. Indeed, instead of bringing out the facts sought, averages conceal them.

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[44] Leighton, M. O. Floods. (National conservation commission. Report, 1909, v. 2, pp. 95–107.)

The method which Mr. Leighton used was that of comparing the annual precipitation with the number of days in each year that the gauge at a given point on a river registered above a certain stage and using the relation of the number of days of flood to the precipitation as an indication of the changes in the regimen of a given river during two periods under observation. Results were worked up for decades as well as for each individual year, since the former bring out more clearly the trend of the changes. The data analyzed by Leighton relate to the Ohio River at Wheeling, W. Va., and to its three principal tributaries, the Allegheny, the Youghiogheny, and the Monongahela, and to the Wateree River above Camden, S. C., the Savannah above Augusta, Ga., the Alabama above Selma, Ala., the Connecticut at Holyoke, Mass., and the Tennessee River above Chattanooga. These records were presented in the form of a series of diagrams, which show that during the period 1885–1907, inclusive, the ratio of high-river stages to annual precipitation increased on the Ohio Riven at Wheeling, W. Va., from 0.38 in the period between 1885–1895 to 1.48 in the period between 1896–1907. The Allegheny River at Freeport, Pa., showed for the period 1874–1907, inclusive, an increase in the ratio from 0.86 in the first half to 1.04 in the second half. For the period 1886–1907 the Monongahela River showed an increase of the ratio from 0.49 in the first half to 0.55 in the second half. In the Youghiogheny River there was also an increase of from 0.35 in the first half to 0.47 in the second half of the period 1875–1906, inclusive. The southern rivers showed similar increase in the ratio of high-river stages to annual precipitation. For the Wateree River at Camden, S. C., this was from 0.41 to 0.51; for the Savannah at Augusta, Ga., from 0.24 to 0.29; for the Alabama at Selma, Ala., from 0.18 to 0.28. In the Connecticut at Holyoke, Mass., there was also a marked increase of from 0.86 during the period 1874–1890 to 0.95 during the period 1891–1907.

In obtaining the ratio between the number of days of high river stages and the annual precipitation, Leighton divided the number of days in each year that the gauge at a given point on a river registered above a certain stage by the total annual precipitation. For the Tennessee River, however, he compared the number of flood days with the number and depth of flood-producing rains. The latter method is the more accurate, but because of the enormous amount of labor involved it was applied only to the Tennessee River. The results secured for this river show that, although during the last half of the period studied the number of days of flood were less than during the first half, the rainfall decreased in an even greater degree. A comparison of the average annual river stages for the two consecutive 12-year periods for which coextension records of stream flow and precipitation are available would show a decrease in the high river stages during the second period. By comparing, however, the number of days of high river stages with the number of days of individual rain storms of sufficient magnitude to produce flood conditions, Leighton brought out the fact that there has been an increase in the number of high river stages in proportion to the rainfall, the average percentage of increase in the last 12 years as compared with the 12 years previous being 18.75.

In analyzing the causes of this marked change in the behavior of a large number of streams, Leighton found that the cutting of the forest on the watersheds of these rivers is responsible for the change in their regimen, as all other factors, such as climate, topography, and geology remained the same, and no artificial storage or drainage affected in the slightest degree the flow of the rivers under discussion. The same conclusion has been reached by Hall and Maxwell,[45] of the Forest Service, who worked up the records of the Weather Bureau relating to stream gauging and precipitation for 10 important rivers. The results of their survey are given in Table 18.

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[45] Hall, W. L., and Maxwell, H. Surface conditions and stream flow. (U. S.—Department of Agriculture—Forest Service. Circular 176, 1910.)

TABLE 18.—*Flood and low-water records for 10 important rivers*

FLOODS INCREASED

Name of stream	Point of measurement	Area of basin	High-water stages taken in this table	Low-water stages taken in this table	First and second periods of record		High-water data						Low-water data						Precipitation		
					Years	Duration	Number of floods	Day of floods	Average times per year of floods	Average days per year of floods	Times of last period compared with first	Days of last period compared with first	Number of low stages	Days of low stages	Average times per year of low stages	Average days per year of low stages	Times of last period compared with first	Days of last period compared with first	Number of stations	Mean (inches)	Mean annual increase or decrease (inches)
		Sq. mi.	Ft.	Ft.		Yrs.					Per ct.	Per ct.					Per ct.	Per ct.			
Potomac	Harpers Ferry, W. Va.	9,363	12	3	1890–1898	9	19	33	2.11	3.55	[1] 36.80	[1] 72.70	54	1,351	6.00	150.00	[1] 40.7	[1] 25.3	5	36.81	+0.13
					1899–1907	9	26	57	2.77	6.33			76	1,693	8.44	188.00			5	37.97	
Monongabela	Lock 4, Pennsylvania	5,430	20	7	1886–1896	11	30	55	2.73	5.09	[1] 73.00	[1] 82.00	66	912	6.00	83.00	[1] 36.33	[1] 7.33	6	42.25	−.08
					1897–1907	11	52	100	4.73	9.09			90	979	8.17	89.00			6	41.35	
Ohio	Wheeling, W. Va.	23,820	22	5	1882–1894	13	46	143	3.54	11.00	[1] 28.25	[1] 31.50	79	1,333	6.08	112.50	[1] 89.00	[1] 20.75	11	41.74	−.14
					1890–1898	13	32	188	4.54	14.40			110	1,609	8.46	123.70			11	39.90	
Cumberland	Burnside, Ky.	3,739	25	3	1890–1898	9	32	89	3.55	9.90	[1] 34.00	[1] 14.60	61	1,261	6.77	138.00	[1] 6.50	[1] 27.00	3	46.27	−.54
					1899–1907	9	43	102	4.77	11.33			65	1,576	7.17	175.00			3	41.42	
Wateree	Camden, S. C.	5,135	20	6	1892–1899	8	45	147	5.75	18.37	[1] 35.00	[1] 22.00	115	1,164	14.37	145.50	[2] 44.30	[2] 56.40	3	45.46	+.25
					1900–1907	8	70	187	7.75	23.50			64	508	8.00	63.50			3	47.48	
Savannah	Augusta, Ga.	7,300	20	6	1890–1898	9	47	116	5.22	12.77	[1] 23.40	[1] 46.50	70	566	7.70	63.00	[2] 41.00	[2] 48.00	3	48.12	−.17
					1890–1907	9	58	170	6.44	17.77			41	292	3.56	32.00			3	46.58	
Tennessee	Chattanooga, Tenn.	21,418	24	2	1874–1890	17	32	173	1.88	10.18	[1] 3.13	[2] 20.80	71	902	4.17	53.00	[2] 22.53	[1] 8.86	5	53.17	−.37
					1891–1907	17	33	137	1.94	8.06			55	982	3.24	57.70			5	46.83	
Allegheny	Freeport, Pa.	9,220	16	2	1874–1890	17	39	92	2.29	5.41	[1] 35.90	[1] 42.40	99	1,747	5.82	102.70	[2] 8.10	[1] 35.00	4	41.65	−.32
					1891–1907	17	53	131	3.12	7.70			91	1,136	5.35	66.80			4	36.17	

FLOODS DECREASED

Name of stream	Point of measurement	Area of basin	High-water stages taken in this table	Low-water stages taken in this table	Years	Duration	Number of floods	Day of floods	Average times per year of floods	Average days per year of floods	Times of last period compared with first	Days of last period compared with first	Number of low stages	Days of low stages	Average times per year of low stages	Average days per year of low stages	Times of last period compared with first	Days of last period compared with first	Number of stations	Mean (inches)	Mean annual increase or decrease (inches)
Wabash	Mount Carmel, Ill.	26,300	15	3	1890–1898	9	21	351	2.33	39.00	[2] 9.50	[2] 20.50	38	1,365	4.22	152.00	[2] 15.75	[2] 15.00	5	39.54	−0.40
					1899–1907	9	19	279	2.11	31.00			44	1,160	4.93	129.00			5	35.99	
Red	Arthur City, Tex.	40,200	20	4	1892–1899	8	19	87	2.37	10.87	[2] 16.00	[2] 30.00	49	826	6.12	103.25	[2] 83.60	[2] 74.80	5	31.80	−.24
					1900–1907	8	16	60	2.00	7.50			8	208	1.00	26.00			5	29.86	

[1] Increase.

[2] Decrease.

The results indicate that the tendency of the rivers examined is toward greater irregularity in the flow of water. The period for which coextensive records of precipitation and stream measurements exist were divided into two equal parts and a comparison made of high and low water stages for the two halves of the period. Of the 10 rivers examined 8 showed greater river stages in the last half than in the first half of the period. As in Leighton's work, it was not the average annual stages of the rivers which were compared for the two periods, but the actual number of days of high and low river stages and their duration.

Both the Geological Survey and the Forest Service have compared, not the highest floods that have occurred in the two periods under observation, but definite high river stages. Extreme stages of the rivers, such as excessive floods and aggravated droughts, are accidents, due to abnormal conditions or chance combinations of circumstances and can not be relied upon to prove or disprove changes in a stream's regimen. If a stream discharges its water more spasmodically or more regularly than formerly, its habit has changed, whether excessive floods or droughts occur oftener or not. Thus, on the Passaic River, according to the State Geologist[46] of New Jersey, a rate of 24 cubic feet per second per square mile was reached only two or three times during 17 years, for a few days in each case, whereas the stream stood at stages between 0.4 and 1.34 cubic feet per second per square mile on an average of 112 days yearly, and between 1.34 and 3.35 cubic feet on an average of the same number of days each year. It is evident, therefore, that the really important thing to determine on the Passaic would be a cause affecting these moderate stages of the river, as they are of a greater economic value than the extreme stages, which are of infrequent occurrence.

The method employed, therefore, by the Geological Survey and the Forest Service is the only one that could be relied upon to determine whether the river's habit is changing. The results brought out by Leighton, Hall, and Maxwell would be still more convincing if they were based on longer periods of observation, on the actual discharge of rivers, and were accompanied by evaporation records. They are, however, the best available. Moreovr, since in no other country in the world have surface conditions changed on so large a scale and so quickly as in the United States, the effects of forest cover upon stream flow should be very marked, even within the short period for which observations exist. The rivers examined by Leighton, Hall, and Maxwell are not the only ones which show a change in their regimen with a change in the surface cover.

A number of other records exist to show that the flow of water in streams has undergone a considerable change with the change in the surface cover of the watershed, but lack of supplementary records, such as those for the precipitation, make it impossible to show conclusively that this change is entirely due to reduction in the forest cover. Thus, Perkiomen Creek, a large tributary of the lower Schuylkill River, draining 360 square miles, has been measured regularly since 1883. The records show that during the 10 years, 1885 to 1894, the average minimum flow was 20.8 second-feet, while in the

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[46] Vermeule, C. C. Forests and Water Supply. (New Jersey—Geological survey. Annual report, 1889, pp. 137–172.)

11 years, 1895 to 1905, it was 17.4 second-feet; or, in other words, that the manimum flow during the last period was 16.3 per cent less than in the first half of the period. The average maximum during the first 10 years was 4,908 second-feet, against an average maximum of 5,330 second-feet during the 11 years following, or 9 per cent greater. There has undoubtedly been a considerable change on the watershed of this creek, but the assumption that the less uniform flow during the latter 11 years is due to the change of the surface cover alone can not be safely accepted until it can be shown that all other factors affecting stream flow have remained unchanged during this period.

Rafter[47] found the maximum flow of the Genesee River, whose watershed is entirely deforested, to be over three times as great as that of the Hudson, whose watershed is 90 per cent in forest, and its minimum flow to be just a little over one-fourth as great. The maximum observed flow of the Hudson from 1887 to 1898 was at the rate of 13.2 second-feet per square mile, and the minimum 0.29 second-feet; on the Genesee the maximum flow, 1890 to 1896, was about 40 second-feet per square mile, and the minimum flow 0.08 second-feet.

Farley Gannett[48] mentions an example of two streams in Delaware County, Pa., measured by Henry Birkinbine. These two streams drained adjoining areas, and weirs were placed on each at a point above which the drainage was 1 square mile. One stream flowed through woodland and the other through open country. The measurements showed that, following rains, the open stream flowed almost invariably more water than the forested one, and that during droughts the reverse was the case.

The importance of the underground water in feeding the dry-season flow of streams is very apparent from the behavior of three streams, of which one has a forested, the second a cultivated, and the third a barren watershed, during the different seasons of the year. Table 19, which is taken from the report of the State geologist[49] of New Jersey, gives the computed daily run-off in gallons per square mile during the last eight months of the dry year of 1881.

Table 19.—*Computed run-off, in gallons, daily per square mile, from forested, cultivated, and barren watersheds during the last eight months of 1881*

	Passaic, forested	Raritan, cultivated	Barren, watershed
April	597,000	754,000	631,000
May	297,000	325,000	145,000
June	272,000	272,000	139,000
July	207,000	134,000	22,000
August	140,000	89,000	22,000
September	139,000	87,000	23,000
October	129,000	84,000	22,000
November	127,000	93,000	23,000

In the three spring months, April, May, and June, the forested watershed yielded 61 per cent of its flow for the eight months from

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[47] Rafter, G. W. The application of principles of forestry and water storage to the mill streams of New York. N. Y., 1899.

[48] Gannett, Farley. What stream gaugings indicate as to the run-off from forested and barren areas. (Engineering news, 1910, v. 63, pp. 759–760.)

[49] Vermeule, C. C. Forests and water supply. (N. J.—Geological survey. Annual report, 1899, p. 163.)

April to November, inclusive, while the cultivated area yielded 73 per cent and the barren drainage area 89 per cent. This is the high-water season of most streams and is the season during which the ground storage is taking place. In the next three months the forested watershed yielded 25 per cent of its flow for eight months, the cultivated 16 per cent, and the barren watershed 6 per cent. In the last two months the forested watershed yielded 13 per cent, the cultivated 10 per cent, and the barren 4 per cent. This shows how small is the underground storage in barren watersheds.

On the basis of this difference in the behavior of the three rivers, the State geologist computes that the Passaic River, with its forested watershed, will furnish for nine months of the year per 100 square miles of watershed 45 horsepower, or 10 feet fall, whereas the Raritan (cultivated watershed) will furnish only 41 horsepower, and the barren watershed 28 horsepower. During the other three months the Passaic will furnish an average of 36, the Raritan 32, and the barren watershed 20 horsepower.

Mansfield Merriman,[50] in his survey of the Delaware River between Trenton, N. J., and Easton, Pa., pointed out, even as early as 1873, the great frequency with which high-water stages occured then as compared with the time previous to 1835. Previous to 1835 floods of 12 feet at Lambertville were considered very high, while 14 feet had been attained only three times within the memory of man, in 1776, 1801, and 1814. After 1835, however, water stages of 14 feet became common, while in 1841, 1846, and 1862 three floods occurred, during which probably one-third to one-half more water was discharged than during any previously known. Merriman does not hesitate to attribute this increase of the high-water stages to the clearing away of the forest in the river basins, "which previously exercised a protective action in restraining the percolation of the rainfall through the soil, and thus insured to the river a more even flow of water than at present."

An inquiry among engineers regarding the influence of forest upon stream flow, made by the National Conservation Commission in the fall of 1908, showed that the majority of engineers in this country are of the opinion that forests affect the regularity of flow of water in streams. Of the 171 replies received from active, associate, and junior members of the American Society of Civil Engineers, 151, or about 89 per cent, mentioned rivers and creeks the regimen of which has changed to their knowledge after a reduction of the forest cover on the watersheds. Only about 20 replies were to the effect that personal observations upon the flow of water in rivers showed no direct connection between forests and stream flow.

RECORDS OF EUROPEAN RIVERS

In Europe the effect of forests upon stream flow was pointed out by hydrographers as early as in the thirties of the last century. Thus in 1837, a hydrographer of note, Dr. Heinrich Berghaus, on the basis of his observations upon the Elbe and upon the Oder, from 1778 to 1835, showed that the amount of water in these rivers was gradually decreasing, and attributed it to the destruction of forests, cultivation of the soil, and the draining of swamps. The effect of forests upon stream flow, however, was brought to the front in 1873, when an Austrian hydrographer, Gustave Wex, published the results of a number of actual measurements of the discharge of five of the most important rivers of Europe, the Rhine, Elbe, Oder, Vistula, and Danube. His measurements were confined chiefly to the medium and low stages of these rivers. In table 20 are shown the results of the measurements, reduced to a 50-year period.

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[50] Merriman, M. Survey of the Delaware River between Trenton, N. J., and Easton, Pa. (U. S.—War Dept.—Engineer Dept. Report, 1893, Appendix U 19, pp. 899–921.)

TABLE 20.—*Measurements of flow in five European rivers*

Name of the stream and gauge station	Periods of observation and their duration in years	Decrease in the height of medium stages during the half period of observation		Increase or decrease in the mean flood stages during the half period of observation	Decrease in the height of the mean stages reduced to a period of 50 years	
		Of lowest stages	Of annual stages		Of lowest stages	Of annual means
		Inches	*Inches*	*Inches*	*Inches*	*Inches*
Rhine at Emmerich	1770–1835 (66 years)	13.64	16.91	+0.85	20.65	25.62
Rhine at Düsseldorf	1800–1870 (71 years)	–.62	4.87	+8.84	–.85	6.86
Rhine at Cologne	1782–1835 (54 years)	7.42	4.40	+15.44	13.78	8.14
Rhine at Germersheim	1840–1867 (28 years)	Unknown.	17.12	Unknown.	Unknown.	61.16
Elbe at Magdeburg	1728–1869 (142 years)	29.86	31.92	–9.27	16.23	17.35
Oder at Küstrin	1778–1835 (58 years)	9.78	10.43	+1.61	16.75	17.97
Vistula at Marienwerder	1809–1871 (63 years)	28.48	16.99	–1.63	45.21	26.98
Danube at Vienna	1826–1871 (46 years)	5.19	8.71	–10.37	11.73	18.94
Danube at Orsova	1840–1871 (32 years)	15.20	18.14	–11.41	47.49	56.70

The records adduced by Wex show that the lowest and the annual stages, and therefore the discharge of the five principal rivers of central Europe, whose total basins have an area of about 586,751 square miles, have been continually decreasing during a long series of years. He ascribes the decrease of water in these rivers to the decrease in the amount of precipitation under the influence of forest destruction, increase in the area of tilled land, and increase in the consumption of water by the increased population. Wex's book, which appeared in western Europe at the time when the flood of 1872 was still fresh in the memory, and while the country was experiencing a severe drought, made a deep impression and aroused great interest, although his conclusions in the light of more recent investigations are no longer tenable. While the fact of a general lowering of the water level of the main European rivers could not be established, there was almost a unanimous opinion that the regimen of the European rivers had undergone a considerable change.

This is the attitude which has been taken by the Imperial Academy of Sciences at Leningrad, the Royal Academy of Sciences at Copenhagen, by the Society of Austrian Engineers and Architects, and by such prominent scientific men as Markham, Hahn, Wanger, Humboldt, Berghaus, Ebermayer, Grollger, and Branders in Germany; Colvert, Arago, Malte-Brum, Dumas, and Becquerel in France; Herschel, Dove, Glaisher, Milne-Holne, and Bergmore in England.

The objections raised to Wex's conclusions were based on the fact that he compared the mean annual medium and low-water stages. It has been pointed out that an average river stage can not be a reliable measure of the actual discharge of the river. The water stages may decrease, yet the total discharge of the rivers may remain the same, as when the river beds are deepened or a change in the slope caused by river improvements takes place. Therefore, even if the height of the medium and low-water stages decreases, this does not furnish reliable proof that the total discharge has also decreased. The only way to determine with certainty whether a decrease in the volume of water has taken place is to measure directly, for a long period of years, the actual discharge of rivers and streams. It has been especially emphasized that a diminished height of medium and low-water stages may be produced by an increase in the height of high-water stages, or, in other words, that the regimen of the rivers might undergo a change without a decrease in the total annual discharge. This criticism of Wex's data applies to most of our stream measurements of to-day.

Louis Torelli, in his work published in 1873, brought together observations and facts gathered in Italy of the injurious effects of clearing of forests upon stream flow. Thus, according to him, the volume of water at the lowest stage of the River Sele had decreased 33 per cent during 150 years; that of the River Brenta at Bassano, 7 per cent between 1684 and 1877; and that of the River Adda, 13 per cent between 1842 and 1862. Basilari, vice presideent of the board of public works, in Italy, in his report submitted to the Italian Government, in 1876, "On the Destructive Floods of the River Po," after a very careful hydrographic survey of the whole valley, came to the conclusion that the floods of the river had constantly increased in height, especially during the last century, and that one means by which the height of these floods could be diminished, or at least the increase stopped, was suitable laws prohibiting the destruction of forests.

Such a noted meteorologist as Professor Ebermayer, after a careful study of the different effects of the forest, pointed out in 1873 that the wealth of forests and the water supply of a country are closely bound together; that springs and creeks dry up the flow only periodically; that the mean stages of rivers and creeks diminish in height when large clearings are made in the forest; and that, on the other hand, springs flow more copiously and regularly when new trees are planted and forests are increased in extent.

Europe abounds in many historic proofs of the influence of forests in regulating stream flow. The rivers Durance and the Seine were navigable at the time of the Roman rule in France, while at present, their watersheds having been cleared of forests, the Durance can hardly float a skiff in summer, and the Seine, in which the difference between high and low water stages is now over 32 feet, was only made navigable again by the construction of numerous wind dams.

The Loire was formerly a navigable river of the highest order, which afforded sure communication between Nantes and the central Provinces. In 1551 the Marquis of Northumberland, ambassador from England, went from Orleans to Nantes "with his suite in five large, many-cabined boats." Now navigation on the Loire above Saumur is impossible. The bed of the river has risen enormously because of the large volume of detritus, brought from the mountains of the central plateau, that it carries with every flood. The remains of Roman villas recently discovered on the shores of the river are several feet lower than the present level of the river.

Forests cover hardly 13 per cent of the area of the drainage basin of the Loire, which is composed of impermeable ground. The many denuded slopes are favorable to surface run-off. On account of deforestation the Loire is in summer nothing but a great stretch of sand. When a storm comes, or a sudden thaw in winter, or prolonged rains in autumn "every depression of the ground gathers a torrent, every ravine confines a river, and all these waters, accumulating in the valley of the Loire, form a roaring sea which reminds one of the great rivers of America."[51] At Roanne the flow at low water and the flow at times of flood is in the ratio of 1 to 1,458. Five days are sufficient to restore the almost dried-up river and to raise the water level to 20 or 23 feet.

In Russia the noted meteorologist, Woeikov, from the records collected on the River Volga, the largest river in Europe, for the period between 1828–1868, computed the changes which took place in the length of time, first, between the opening of the river and the beginning of high water; second, between the opening and the maximum flow of the river; third, between the opening of the river and its normal flow; and fourth, the changes in the maximum river stages. He computed his data by decades and came to the conclusion that high waters in the latter part of the period under observation began earlier than in the forties. The duration of the high-water stage had become longer and the height of the spring floods had increased. He attributed this change in the regimen of the river to the destruction of the forests upon its watershed.

RECORDS OF RIVERS IN BRITISH INDIA

In British India there are many reliable records of changes in the regimen of the rivers because of the destruction of forests. In Bengal the Rivers Koina and Rora, in Singhbhum, both 30 to 45 miles in length, clearly show the influence of forest cover upon stream flow. The River Koina drains a tract of country of which 80 per cent is reserved forest and holds a plentiful supply of water throughout the year. The River Rora flows through country almost entirely denuded of forests. Its waters run very low even in the cold weather, while in the hot weather it dwindles away to nothing.

Another striking instance of the influence of forest growth upon the flow of a stream is furnished by Popa Hill in the Myingyan district, Burma. Before the present Popa reserve was formed and the clearing of the hillsides prohibited, the stream which runs by Popa village gave a very precarious supply of water in the dry season, and one year it completely dried up, with the result that the village and the military police post had to be temporarily abandoned. Since the forests on Popa Hill have been reserved and protected from fire, there has always been an abundance of water in the springs during the dry season of the year.

In 1908 an influential committee was appointed in British India to examine the question of denudation of forests in Chota Nagpur and Orissa. The committee considered it proved that streams in Government reserves last longer through the hot weather than streams of the same size in a denuded area, and was so convinced of the importance of preserving the forest that it drafted a bill which is now under consideration, giving the Government power to insist on the protection of forest growth or reforestation on waste lands not the property of the government.[52]

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[51] Castle, M. A., tr. The effect of the forest upon waters. (American Forestry, 1910, v. 16, pp. 156–173.)

Records at the Swiss Central Experiment Station

The most careful and conclusive evidence of the influence of forest upon the regularity of stream flow is furnished by the Swiss Central Experiment Station. Experiments have now been carried on there for 11 years, or since 1890, and are confined to two watersheds located in the valley of the River Emme. In order to eliminate many of the counteracting factors which are found on a large drainage basins the Swiss Experiment Station selected for its study similar watersheds, one with an area of about 140 acres, the other about 175 acres. The two watersheds are as similar in topography, geological formation, soil, and latitude as could be found. The only difference is that one of them is completely wooded (98 per cent); the other is only partially wooded (30 per cent). Accurate measurements of rainfall, snow, run-off, and temperatures are carried on by means of ordinary and self-registering instruments. The two streams are measured continuously by a self-recording instrument installed by the Hydrographic Institute of Switzerland.

The final results of this experiment are not yet published, since the aim is to include records of excessively dry and wet years. So far the station has secured records for extremely dry years, but no records of exceptionally wet ones. The preliminary report made by Professor Engler at the International Association of Forest Experiment Stations in 1906 shows, first, that at the time of the maximum of high water the channel of the deforested region carries from 30 to 50 per cent more water per unit of surface than the wooded region; second, that after prolonged dry periods the springs of the deforested region dry up completely and the bed of the stream is dry, while the stream from the wooded valley is still yielding at least 5 liters of water per second; third, that the forest performs the beneficial function of equalizing the flow through the year in dry and wet periods without diminishing the total yearly discharge of the streams; in other words, that the amount of water discharged by the two streams during the year is about the same.

Report of the Tenth Congress of Navigation

The views held by the hydrographic engineers of Europe were fully expressed at the Tenth Congress of the Permanent International Association of Navigation, at Milan, in 1905. One of the subquestions considered at this congress was the influence which the destruction of forests and the drainage of marshes has upon the regimen and discharge of rivers. Seven reports upon this question were submitted, six of which were summarized in a general report.[53]

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[52] Influence of forests on drought. (Indian Forester, 1911, v. 37, pp. 477–489.)

The general report shows that the engineers were unanimous upon the following points:

1. Forests increase the mean low-water levels of rivers and make their flow more uniform at ordinary stages.

When situated on impermeable soils and on slopes, forests form and maintain springs.

3. Forests hold the soil on slopes and so prevent destructive erosion and its consequences.

Regarding impermeable soils, the engineers were agreed (except the representative from Austria) that forests facilitate the storage of water by the soil, and are therefore favorable to the formation and maintenance of springs. None of the engineers denied the advantageous influence of forests upon stream flow during the low-water, high-water, and ordinary flood stages.

One of the engineers representing Austria, Mr. Keller, held the opinion that arable lands must be considered to be more favorable for the replenishment of subsoil water than forests are, but in connection with this conclusion he advanced an argument which is of the utmost importance in any public-land policy. Arable land, he contended, retains its water-storing capacity only when it is worked under scientific systems of agriculture. Since it is always doubtful whether such systems will be applied and continued, deforestation implies a menace to the storage capacity of the soil. He points to Asia Minor and to many Provinces of southern Italy which were formerly rich and flourishing, but are now arid and waste, and ascribes the deterioration not to deforestation, but to the decay of agriculture.

The chief engineer of the Genio Civille, Italy, drew a radical distinction between permeable and impermeable soils. On impermeable soils the forest cover, by allowing the railfall to drip slowly to the ground and by preventing its rapid surface run-off, induces the water to sink gradually into the ground. He cited numerous instances in Sardinia, the basin of the Adda, the Province of Benevento, and other places in Italy, where all springs on impermeable soils disappeared after the forests had been destroyed. On highly permeable soil, however, he did not attribute to the forests any effect upon the storage of ground water. On the contrary, he held that forests on such soils may be even detrimental to direct absorption of water, as in the case of fissured or porous limestones. Thus, on the permeable limestone he claimed that from 75 to 80 per cent of the rainfall is absorbed by the soil directly, an amount which could not be absorbed by any vegetable cover.

All the engineers, without distinction, admitted that the deforestation of sloping lands, unless the lands are afterwards kept under some substitute cover of equal efficiency, causes erosion, and in many places landslides and avalanches. This conclusion was reached both directly and indirectly. It was supported both by positive and negative evidence. Thus, the enormous damage by erosion which followed deforestation in Sardinia and other Italian Provinces was noted by Ponti and others, while Lafosse pointed to the marked improvement which has taken place in the regimen of rivers in France since the State has successfully reforested several million acres in their catchment basins.

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[53] The seven individual reports were by: Mr. H. Keller, privy councillor, department of public works, Austria; Mr. H. N. R. Lafosse, inspector of rivers and forests, France; Mr. V. Lokhtine, engineer, Russia; Mr. Ponti, chief engineer of the Genio Civille, Italy; Mr. J. Riedel, engineer, technical councillor at Vienna, Austria; Mr. J. Wolfschütz, agricultural councillor in Brunn, Austria; Mr. E. Lauda, engineer, senior councillor of construction, etc., of the Hydrographic Office, Vienna, Austria.

The general report, which failed to consider Mr. Lauda's paper, was prepared by Mr. Cesare Cipoletti, an Italian engineer.

It was pointed out that damage from erosion is most severe in small and narrow basins and where the subsoil is impermeable. Landslides and avalanches are most likely to occur where the forest is removed from ground that is marly, sandy, or composed of fibrous rocks. The damage will be less serious if the cleared land is left as a meadow and is not broken up with the plow, or if steep slopes are eased off by terraces, or if the speed and force of the run-off is broken by contour ditches, such as the so-called gira-monti in Italy. At the same time such artificial aids may not prove efficacious. Their construction and maintenance are as a rule costly, and they may not be used at all; or if used, may be neglected, and in that case the logical effect of deforestation will make itself felt in the land waste which Keller points out has followed the decay of agriculture in regions that have been thus abused.

Total Discharge of Streams

In discussing the relation of forests to stream flow a clear distinction must be made between total annual discharge of a river, or average annual discharge, based upon observations for a number of years, and the actual behavior of the stream during the different seasons of the year. The total discharge of a river, or its average annual discharge, or its average annual stages may remain the same throughout a series of years, yet its regimen may be so changed that its usefulness is greatly impaired either for water power or navigation. It is very necessary to keep in mind that the average height of a river is not a reliable measure of its actual average annual discharge or of its total discharge. The average annual river stages may remain the same, yet the average annual discharge may increase or decrease, or vice versa.

Thus Ule,[54] from an actual comparison of the water stages and the flow of water in the River Saale for March, 1896, has shown that while on the basis of the mean water stage the flow was computed on 378,000,000 cubic meters, the daily measurements gave 508,000,000 cubic meters, or 34 per cent more. The mean water stage in March was 2.13 meters and in December 2.15 meters, yet the amount of flow in the month of March was 23 per cent smaller than in December. These figures show how unreliable are the readings of average river stages for determining the actual discharge of the rivers. If the flow of water in a stream is compared with the precipitation over its watershed for a number of years, there will be found a similarity between the fluctuation in the flow of water and that of the precipitation. On the whole, the amount of water carried by a river depends upon precipitation and temperature. It is greater when the temperature is low, though the precipitation is scant, than during years of greater precipitation but of higher temperature. Large rivers are least affected by climatic fluctuations, because their large watersheds exercise an equalizing influence upon the ununiform distribution of precipitation. That the flow of water in streams depends largely upon climate is now a fact accepted by meteorologists, engineers, and foresters, and is supported by very careful observations on a number of rivers, especially in Europe.

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[54] Ule, W. Theoretische Betrachtungen über den Abfluss des Regenwassers. (Zeitschrift für Gewässerkunde, 1905, v. 7, 65–86.)

The geologist and hydrographic engineer, Doctor Penck,[55] has, more than anyone else, been instrumental in showing, by actual measurements of stream flow, precipitation, and evaporation, the dependence of the total amount of water carried by rivers upon precipitation and temperature. His studies of the River Danube, and especially of the Elbe, led him to the conclusion that the rivers of central Europe depend for their flow upon precipitation. He found that the total run-off in the rivers of central Europe forms about seven-tenths of the precipitation above a certain minimum (16.38 inches). If precipitation fell below this minimum no water would be available for stream flow. Practically the same thing has been found to be true by F. H. Newell[56] for the run-off of North American rivers. Here the minimum of precipitation below which no run-off would take place is 11.7 inches. Of the precipitation remaining above this minimum eight-tenths runs off into the rivers. In order to show the relation between total run-off and precipitation, Newell used two maps, one showing the total run-off from land in the various large divisions of the country and the other the mean annual precipitation. The run-off has been expressed by depth in inches over the whole catchment basin. While the two maps do not coincide exactly, yet there is a close similarity between the depth of run-off and the mean precipitation. Thus, in the central regions of the United States, where the run-off ranges from 0 to 2 inches, it forms 10 per cent of the precipitation; where the run-off is from 2 to 5 inches, from 10 to 25 per cent; where it is from 5 to 10 inches, from 40 to 50 per cent; and, finally, where the run-off is 20 inches and over it represents over 50 per cent of the rainfall. This relation between total run-off and precipitation, modified by topography, shows clearly that the total amount of water in the rivers depends first of all upon the climate of the region. Similarly, a German engineer, Scheck, has shown that the per cent of run-off in the European rivers decreases from west to east (in accordance with the decrease in precipitation), from 0.4 for the Rhine to 0.2 for the Memmel.

The rivers of a country, therefore, are the result of the climate, and fluctuations in the total amount of water carried by them must depend upon climatic fluctuation. Without a general change in the climate there can be no general decrease of water in large rivers.

Professor Brückner, from a mass of evidence collected by him, has shown that there exist climatic cycles with cool and humid, and dry and hot years, and that the variation in the yearly discharge of rivers must be attributed to the climatic fluctuations. Thus, according to Brückner, in Europe the periods between 1806–1815, 1841–1855, and 1871–1875 were humid and cool, and the highest water in the rivers occurred in 1815 and in the five-year periods between 1846–1850 and 1876–1880. The periods between 1820–1840 and 1856–1870 were warm and dry, and the water during the five-year periods between 1831–1835 and 1861–1865 was at its minimum. The presence or absence of forests, therefore, can have no influence upon the mean annual flow of water in large rivers.

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[55] Penck, A. Die Flusskunde als ein Zweig der physikalischen Geographie. (Zeitschrift für Gewässerkunder, 1898, v. 1, p. 4.)

[56] Newell, F. H. Results of stream measurements. (U. S. Geological Survey. 14th annual report, 1892–93, pt. 2, pp. 89–155.)

In many quarters there exists an impression that foresters claim that wooded watersheds have an effect upon the total yearly discharge of water in streams, and that with the destruction of the forest the total discharge or the average annual discharge of water must inevitably decrease. As a matter of fact, foresters have never made any such claim. On the contrary, they were the first to point out the possibility, under certain conditions—for instance, in a semi-arid region—of a wooded watershed consuming a larger amount of water than a bare watershed or one covered with low vegetation, and in this way diminishing the total amount of water available for stream flow during the year.[57]

Any figures, therefore, which show that the average annual water stages of actual average annual discharge of water in a stream remain the same, irrespective of change in the surface cover of the watershed, do not prove in any way that a forest has no influence on the behavior or the regularity of the flow of water in streams.

Seasonal Variation of Stream Flow

While precipitation is responsible for the amount of water in the streams, the relation between precipitation and the river stages during the year is not direct or immediate. Prof. D. W. Mead,[58] in his study of the Wisconsin rivers, points out that rainfalls of 3 or more inches per month during the early portions of the year give rise to a flow of considerable magnitude, whereas even greater rainfalls during the summer months have little or no effect in augmenting the flow of the stream. During the period between December and May the winter snow and the spring rains saturate the ground. This is the storage period. During June, July, and August the rainfall is rarely sufficient to take care of evaporation and plant life, and the stream flow is therefore usually dependent entirely on the ground water. The ground water begins to furnish more or less of the stream flow as early as May. Professor Penck found, for the Elbe, that during the months of August, September, October, November, December, and January there is going on a storage of water in the form of snow and underground waters, while in the months of February, March, April, May, and June the stored water is gradually fed out and sustains the flow of water in the river.

From a table worked up by him for the Elbe, it follows that if there was no storage of water in the form of snow and underground water during the period between the months of August and January the discharge of the river in April would be near zero, and in May it would stop flowing entirely. By actual measurements of the discharge of water in the Elbe and of the precipitation over and evaporation from its watershed for 15 years, Penck found that one-third of the total precipitation goes into the river. Of this one-third, two-thirds reach the river as surface run-off and the remaining one-third, or one-ninth of the total precipitation, reaches the river as underground water. The highest stages during the early spring are the direct consequence of the accumulation of underground waters during the fall and winter. The accumulated underground water is gradually fed out during the early summer. It is evident, therefore, that if the total amount of water carried by the river during the entire year depends upon the amount of precipitation, the amount of water carried by a stream during the different seasons of the year depends upon the storage capacity of the watershed, whether the storm waters reach the river as soon as they fall or are retarded in their flow and reach the river as underground seepage at a time when precipitation is lacking or scant. The flow of water in the stream during the summer is sustained by the underground water stored at the time of excessive precipitation.

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[57] Toumey, James A. The relation of forests to stream flow. (U. S. Dept. of Agriculture. Yearbook, 1903, pp. 279–288.)

[58] Mead, D. W. The flow of streams and the factors that modify it, with special reference to Wisconsin conditions. (University of Wisconsin. Bull. 425, 1911.)

FORESTS AND SPRINGS

The forest cover, among other factors, affects the storage capacity of a watershed and is instrumental in sustaining the flow of water in rivers at times when precipitation is lacking or is just sufficient to cover evaporation.

The effect of forest cover upon the sustaining of springs and the flow of water during the dry part of the year is well brought out in the annual report of the State geologist[59] of New Jersey for the year 1899. A comparison of the amount of water, expressed in inches of rainfall, that reaches streams through underground seepage from forested, cultivated, and barren watersheds during a dry period, when the rainfall is equal to the evaporation and therefore the effect upon streams is eliminated, give the results shown in Table 21.

TABLE 21.—*Yield of springs on forested, cultivated, and barren watersheds during drought*

Month	Forested watershed, Passaic	Cultivated watershed, Raritan	Barren watershed
First month	1.16	1.43	0.94
Second month	.54	.64	.38
Third month	.40	.45	.26
Fourth month	.33	.35	.20
Fifth month	.32	.30	.14
Sixth month	.31	.27	.12
Seventh month	.30	.25	.10
Eighth month	.29	.23	.08
Ninth month	.28	.22	.07
Total	3.93	4.14	2.29

These figures, which are the result of computation based upon actual guagings, show that while the cultivated and forested watersheds yield almost the same amount, the cultivated watershed gives off its water faster during the first months, and therefore, sooner becomes exhausted. The barren watershed, whose underground storage capacity is small, has little flow for springs, which almost dry out toward the end of the drought.

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[59] Vermeule, C. C. Forests and Water Supply. (New Jersey—Geological survey. Annual report, 1899, p. 162.)

Europe abounds in authentic historic records of the disappearance of springs as a result of deforestation. Edward Ney,[60] forester and hydrographer, of Alsace, in a paper published in 1875, mentioned that in the Provence, after all the olive trees, which there formed regular forests, and which were frozen in 1822, had been cut down, a great number of springs failed entirely, and that in the city of Orleans, after the surrounding heights had thus been cleared, nearly all the wells dried up, making it necessary to conduct the headwaters of the River Little Loire into the city.

A Swiss engineer and hydraulic expert, Robert Lauterburg,[61] who collected a large number of exact data relative to the discharge of rivers in Switzerland, found, on the basis of accurate measurements of the discharge of springs, that in the Melasse formation, within an area of 0.29 of a square mile, the springs in wooded portions discharge from five to ten times more water than those in the clearings.

The springs of Bresle dried up about 1840, after clearing off a forest of some importance situated in the parish of Formerie (Oise). Soon after the forest of Cressy was cut in 1837 the source of the Arrivaux River descended toward Breuil (Somme) 1 kilometer. Clearings made in the forest of Arronaise were injurious to all the streams that flowed from it to Escaut and Somme.

After the death of Don Bouthillier de Rancé, the abbé of la Trappe leased the iron works connected with the monastery to private parties for 12 years. It was necessary, according to the biography of Don Pierre the Dwarf, subprior of the monastery, "to destroy the forests of la Trappe in order to maintain the furnace fires, and it is impossible to tell how far-reaching the effects were. The springs soon dried up and the ponds yielded water only six weeks in the whole year." This was written in 1715.[62]

Near the little village of Orgelet (Jura), at the foot of the east slope of the Orgier Mountain, in the parish of Plaisia, there is a spring called the Fountain of Plaisia, which disappeared during the entire time that the mountain remained cleared of its forests (from the end of the eighteenth century to the middle of the nineteenth), and reappeared 30 years ago, when the work of the reforesting the slope had been finished. Numerous inhabitants of the country testify to this fact.

According to the testimony of the mayor of Flacey (Côte d'Or), the spring supplying this village had always had a constant and regular flow as long as the limestone uplands, from the foot of which it issued, remained covered with a coppice of vigorous oak over an area of 100 hectares. At the beginning of the nineteenth century, the area having been deforested, the spring no longer had a regular flow, and was entirely dry the greater part of the time.[63]

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[60] Ney, E. Ueber den Einfluss des Waldes auf die Bewohnbarkeit der Länder. Prag. 1875.

[61] Lauterburg, R. Ueber den Einfluss der Wälder auf die Quellen und Stromverhältnisse der Schweiz. Bern, 1875.

[62] Mr. E. Charlemagne has given an instance to the point in the Revue des Eaux et Forêts of the disastrous effects that the heedless cutting of forests may have upon stream flow.

De Rothenbach, director of the water service of the city of Berne, made observations on the flow of the springs of that city. Expressing the minimum as 1, the flow per minute of two of them, the Schliern and the Gasel, varied from 1 to 2.7 and from 1 to 4.1, respectively, while the variation of a third spring, that of Scherli, was from 1 to 6.7. The basin of the springs of Gasel and Schliern is sheltered by a considerable mass of forests, while that of Scherli comes from a mountain partly deforested. Other observations tended further to show that the forest during dry times gave out slowly the water it had stored up during a rainy period. Thus during the summer of 1893, which was marked by a long and destructive dry period, the spring of Scherli reached its smallest flow September 3, 1893, but that of Gasel not until three and a half months later, and that of Schliern six and a half months later.

In Algeria the trees disappeared and the springs dried up. In the Canton of Bouffarik, formerly noted for its rich water supply, 15 springs decreased in two years from 1,316 to 710 liters; rivers such as the Oued Chemla, which had a flow in 1864 of 150 to 180 liters, no longer yield more than from 70 to 80 liters; the Oued Kremis, which had a flow in 1864 of from 100 to 200 liters, in 1881 had a flow of only 15 liters. The water supply of cities like Saint-Denis-du-Sig disappeared, and water was shipped in over the railways. The water in the canals of the city of Algiers diminished from year to year. At the gates of the city a striking example of the dearth of water can be observed. Thirty years ago the Oued M'Kacel, in its cool valley, had the power to turn four mills; to-day water and mills have disappeared with the forest that covered Mount Bouzarea.

The eminent geographer, Onesimé Reclus, cited the example of the city of Tunis, which was formerly supplied with pure water from the springs issuing from Mount Zaghouan, springs that have disappeared since the mountain was deforested.

The flow of the streams diminished notably at Martinique after the island was deforested for charcoal. In the same way water in the canal built in 1867 by Admiral de Gueydon to convey good water to Fort-de-France diminished considerably, and the Government of the colony has very recently adopted measures to check the deforestation. (Castle.)

Mr. Crahay, inspector of waters and forests at Brussels, noticed at Planchimont that the flow from the springs of La Sure became more regular after the region has been reforested with spruce for 40 years. "One of them," he wrote, "that gave no water during the summer, never dries up now, and issues 70 meters higher on the slope than did the former spring. At Bois-le-François, parish of Villiers-devant-Orval, after the clearing of an old coppice forest two springs disappeared. The place where the water issued and the little channel that it followed down the slope can still be seen."

At the International Congress of Silviculture, held at Paris on the occasion of the exposition of 1910, Grebe, forester councilor at Eisenbach (Alsace), cited numerous examples of springs that had dried up or of diminutions in stream flow noticed after deforestation in central Germany. He told also of cases where springs reappeared after reforestation had taken place. Another German forester, M. B. A. Bargmann, told of the disappearance of two springs in the valley on St. Amarin (Alsace) after clearings had been made above them.

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[63] Mathey, A. Influence des Forêts sur le débit et la régularité des sources. (Revue des eaux et forêts, 1898, v. 37, pp. 561–563.)

At the same congress Mr. Servier, a landholder at Lamure-sur-Azergues (Rhone), gave several interesting facts. In the region in which he lives, which until late years was almost completely deforested, he noticed that wherever a cluster of trees remained their presence was coincident with the existence of a spring. The flow of a spring on the western outskirts of a coppice wood diminished continually after the coppice had been cut, but returned to normal when the coppice grew up again.

An inquiry into the influence of forest cover upon springs, made by the National Conservation Commission in the fall of 1908 among foresters and engineers throughout the country, revealed a remarkable unanimity of opinion on this point, and brought to light numerous instances of the drying up of springs as a result of forest destruction.

" Springs near Odessa, N. Y., have had their flow decreased 50 per cent as a result of forest destruction." (H. A. Paine, Denton, Md.)

" Streams are lower in every case in Vermont where the virgin timber has been cut, and new growth does not help this condition until it gets large enough to completely cover the ground and high enough to afford perfect shade and admit circulation of air under the branches." (H. D. Packer, West Burke, Vt.)

" Captain Miller, an old settler in Alamogordo, N. Mex., states that a large spring at the head of the La Luz Canyon dried up after logging at its watershed in 1899." (A. M. Neal, Alamo National Forest, Alamogordo, N. Mex.)

" In north Georgia it has been noticed that in many cases streams have perceptibly lessened in flow since the destruction of the forest. In many cases large streams have dried up." (S. W. McCallie, Geological Survey of Georgia, Atlanta, Ga.)

"At Truckee Ranger Station, Tahoe National Forest, is a spring never known to go dry before July, 1908. The timber has been almost entirely removed from the watershed and the snowfall is also much less than in former years. In another part of the forest is a spring which flowed throughout the year previous to the removal of the timber in 1902. In August, 1905, the spring contained some water, but none was flowing on the surface of the ground. Still another spring is now dry about 3 months in the year, whereas previous to the removal of the timber 10 years ago it was never known to go dry." (M. B. Pratt, Tahoe National Forest, Nevada City, Calif.)

" Glens Spring, near Fremont, Ohio, in 1879 had a daily discharge of 35,000 gallons. It is now reduced to less than 1,000. Muscalounge Spring has had its flow reduced from 140,000 to 2,000 gallons. Numerous other springs near Fremont which flowed profusely before 1890 have now dried up completely, undoubtedly due to deforestation." (C. O. Lasley, Fremont, Ohio.)

"Flow of streams on Big Pryor Mountain have diminished greatly in the last 5 years, and many have dried up entirely in July. Forest of lodgepole pine was removed." (V. G. Langtry, jr., Absaroka National Forest, Livingston, Mont.)

"Several small springs east of Marysvale, Utah, previous to 1901 had sufficient flow to water large herds of cattle and maintain a steady flow. Since then overstocking of range and removing grass covering have caused the springs to dry up, until they are of practically no use." (C. S. Jarvis, 33 East Second Street, South Provo, Utah.)

"All springs in the Manti National Forest now flow more freely than ever before the creation of the forest. The formation is limestone. The forest cover has now returned." (A. E. Jensen, Manti National Forest, Ephraim, Utah.)

"In Stonelick Township, Ohio, there was a spring which during the Civil War flowed regularly and freely, but has now ceased to flow. It is located at the foot of a high hill on which the timber has been cut and which may be the cause of the stoppage in the flow of water." (G. H. Hill, box 26, Milford, Clermont County, Ohio.)

"Spring Gulch, near Providence, Ariz., had always had a steady flow until the timber surrounding it was cut, when the water ceased to flow during the dry months." (J. D. Guthrie, Prescott National Forest, Prescott, Ariz.)

"The cutting of forests in Newport, Ky., has resulted in drying up of springs which old residents say used to flow throughout the year." (W. L. Glazier, Newport, Ky.)

"Numerous springs in Pike National Forest have dried up as a result of cutting timber. One spring in particular, which flowed throughout the year for 30 years, entirely dried up after clearing the timber from 360 acres about it.

"On the west branch of Michigan Creek, Colo., several streams which previously flowed all the time are now dry as the result of cutting.

"Since the severe fire in Calahan Gulch, Pike National Forest, Colo., several springs have entirely dried up." (C. W. Fitzgerald, Pike National Forest, Denver, Colo.)

"In Caribou, Me., is a spring which in 1880 was large enough to be used as part of the water supply of the village. Since the cutting of the forests on its watershed its flow has materially decreased, and in 1904 was practically dry." (A. C. Hardison, Santa Paula, Me.)

"Many years ago the springs near Iowa City, Iowa, flowed throughout the year. Since the cutting of the timber they have entirely dried up." (Clark R. Fickes, C., B. & Q. R. R., Chicago, Ill.)

"Many springs near Meadville, Pa., have been dried out in recent years, and many wells are much deeper than formerly, due to deforestation." (W. A. Doane, Meadville, Pa.)

"Since the cutting away of the timber on the hillsides near Leadville numerous springs which flowed all the time have dried up and the snow melts much earlier in the spring." (J. W. Deen, Denver & Rio Grande Ry. Co., Salida, Colo.)

"Springs near Wilmington, Mass., dried up as a result of cutting pine forests. Where these were cut 20 to 30 years ago springs have begun to flow again." (W. W. Cummings, Boston, Mass.)

The most direct evidence, however, of the effect of extensive clearing upon ground water has been recently brought out by Dr. W. J. McGee.[64] During a period of about 22 years 9,507 wells in the States of Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Ohio, Tennesse, and Wisconsin show a lowering of the water table at a minimum mean rate of 1.315 feet, or, with moderate allowance for new wells, 1.73 feet per decade, corresponding to a total of 13.8 feet for the 80 years since settlement began. The loss, according to Doctor McGee, is due largely to increased run-off in freshets and floods, which are in increasing degree weakening destruction of property and loss of life, while innumerable springs and smaller-source streams have disappeared, and the regimen of nearly all streams has been impaired.

These facts tend to show that there is a most intimate relation between forest cover and underground water, and as the continuity of stream flow depends wholly upon the water stored in the ground, the effect of forests upon the regularity of stream flow becomes evident.

FORESTS AND FLOODS

High floods are caused in large navigable rivers either by excessively heavy or by long-continued rains. During the first hours of heavy rainfall, and often during the precipitation which may precede it, the forest floor becomes so completely saturated with water that it allows any further rain to pass off just as it would from open ground. The influence of the forest on the prevention of catastrophies from high water and floods is therefore limited. The forest can prevent smaller floods by retaining a certain amount of water and retarding the flow, but it is powerless to prevent greater ones. The latter are the result usually of either a large quantity of rain falling on frozen or saturated ground covered with snow, especially in late winter, or an unusal amount of rainfall, even for a short period, in the territory drained.

Since the amount of water which the forested soil can absorb or retain is small as compared with the amount which it receives during a downpour, or with a sudden thaw, it is evident that under exceptional meteorological conditions the retentive capacity of the forest floor must fail. Forests can absorb a quantity of water corresponding to a precipitation of 0.16 of an inch, or, in very favorable conditions, of 0.24 of an inch. According to Bühler, the highest amount beech foliage can absorb is 18,000 liters per hectare (7,200 liters per acre) and moss 24,000 liters per acre, corresponding to a precipitation of 0.07 and 0.24 inch, respectively. Ebermayer estimates that dry litter in beech forests absorbs an amount equal to 0.09, in pine forests 0.05, and in spruce forests about 0.05 inch of precipitation. Ney's results give 0.09 inch for beech forests, 0.15 inch for pine, and 0.07 inch for spruce. According to Riegler, the water absorption by moss amounts to from 200 to 900 per cent of its weight; with foliage it equals 150 to 220 per cent; and with pine needles 120 to 134 per cent. According to Gerwig, moss can absorb from 0.18 to 0.39 inch of water.

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[64] McGee, W. J. Principles of water-power development. (Science, Dec. 15, 1911, pp. 813–25.)

In comparison with these amounts the quantities of water that cause excessive floods are enormous. On March 6, 1896, there fell on the Kniebis in the Schwarzwald 7 inches of rain; in three days (from 6th to 8th of March), 13 inches (flooding of the Dreysam Valley); in Eichberg, Silesia, July 29, 1897, 4.4 inches; from July 28 to 30, 6 inches; on the ridge of the Riesen-Gebirge, July 30 and 31, 8.8 inches (flooding of the Hirschberg Valley); in Munich, September 13, 1899, 3 inches (destruction of the Prinz-Regent Bridge); in the Bavarian Mountains, more than 4 inches.

In Austria, at the time of the high-water catastrophe in July, 1897, in the course of two days, in the Unter Inns district, there was a rainfall of 5.8 inches; in the Traun district, 7.4; and in Vienna, 6.9 inches. In September, 1899, in the course of two days in the Salzach district, the rainfall amounted to 6.7; in the Traun district, 8.3; at Enns, 7.8; ta Ybbs, 8.3; and at Trausen, 6.6 inches. From July 26 to 31 (six days), 1897, in the territory of the Donau River, there was a rainfall of 421,768,000,000 cubic meters; and in September, 1899, within seven days, 565,024,000,000 cubic feet. The total of this land ocean amounted to 1,412,560,000,000 cubic feet.

While the forest is necessarily helpless to prevent the occurrence of excessive floods during periods of exceptional rainfall, yet by protecting the soil against erosion by diminishing the proportion of detritus carried by the run-off, and by absorbing at least part of the water that falls upon the ground, it has a mitigating influence even on the highest floods. The fact that the volume of eroded matter carried by the streams in periods of flood is greatly diminished by the presence of the forest must necessarily decrease the violence of the floods, since sand, gravel, pebbles, and rocks torn from the soil by the stream raise the level of the stream beds and increase the volume of water carried.

There is no lack of facts to establish this moderating action of the forest. Marchand gives an example of a torrent in the canton of Appenzell, Switzerland, which formerly became swollen at Weissenbach about three hours after the storms had burst upon the mountain. Following a partial deforestation of the mountain, the floods became manifest at Weissenbach within one hour after the appearance of storms. The presence of the forest, then, had the effect of delaying by two hours the manifestation of flood and of increasing by four hours the duration of the run-off.

Many streams that descend from the departments of the Vosges Mountains, which still bear a large forest cover, do not have as frequent nor as disastrous floods as the torrents that come down the denuded slopes of the Alps, or the streams of irregular flow that issue from the deforested Cévennes (Ardèche, Lot, Tarn, Dourbie, Loire, Allier), or from the waste lands of the Central Plateau (Cher, Sioule, Creuse). The proportion of forest area of the Vosges is 35 per cent, while that of the Alps of Savoy is 21 per cent, that of the Alps of Dauphiny (Isère, Drome, and Hautes-Alpes) 13 per cent, that of the Alps of Provence (the Lower Alps and Maritime Alps)

12 per cent, and that of the Central Plateau and of the Cevennes 12.2 per cent.

In the Department of Aude, in France, there occurred on September 12, 1893, a terrific storm, which caused considerable damage throughout the whole region. All the tributaries of the River Aude experienced sudden floods, and that river rose 16 feet at St. Marcel. The storm lasted an hour and a half, and there was a rainfall of 2.4 inches. The Blanque River, which unites with the Salz 5.6 miles above Couizo, and which, like it, flows down slopes almost entirely denuded, immediately rose 3 feet and devastated a large amount of property along the river, especially at Rennes-les-Bains. At Couiza the flood was greater, and the frightened inhabitants feared a repetition of the disasters of 1891. In the basin of the Rialsesse, which flows into the Salz 3.6 miles above Couiza, the amount of the rainfall was 2.4 inches also. This river, however, did not overflow nor cause any damage. In contrast to the denuded slopes down which poured the run-off into the Salz and the Blanque was the heavily wooded basin of the Rialsesse, where, to supplement the existing cover, 4,200 acres had been reforested.

At the International Congress of Navigation, in 1905, Cipoletti, an Italian engineer, who prepared the general report embodying the views of the engineers representing the different countries at the congress, maintained that while it is true that during a prolonged rain a moment is at least reached when the run-off to the valley is equal in amount to the rainfall in the forest above, it does not follow by any means that this moment coincides exactly with the moment of the heaviest rainfall. In every instance he found that the balance between run-off and rainfall was reached only when the rain had begun to abate; in other words, the moderating influence of the forest upon run-off continued to act during the critical period, and that without this influence the floods would be destructive in their effect.

In Baden the Government, after disastrous floods of the Rhine and its tributaries in 1882–83, appointed a commission composed of an officer of the central bureau for meteorology and hydrography, an officer of the engineer department, and an officer of the forest department to investigate the relation of forests to floods. This commission, after a most detailed survey, which comprised not only the geographic, climatic, and geognostic conditions of the watershed, but more especially its surface cover, submitted a number of conclusions.[65]

1. The forest cover retards the surface run-off. It retards also the melting of the snow. In exceptional cases, however, this influence of the forest may become ineffectual, namely, during an unfavorable sequence of periods of heavy precipitation, as was the case in the catastrophe of 1882.

2. The binding of the soil by forest cover is entirely beyond dispute and, hydrographically, is of the greatest importance. The forest of the Alb watershed fulfills well its function as a protective cover. The satisfactory condition of the watercourse and valley bottoms and the moderate extent of the damage experienced from the floods of this

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[65] Fernow, B. E. Forests and floods. (Garden and forest, 1890, vol. 3, pp. 9 and 10.)

watershed are due to the small amount of detritus. The soil conditions being extremely favorable to the formation of detritus and rock chutes, their absence can only be due to the forest cover on the declivities. Where masses of detritus and waste rock and lanslide material were found (on about 60 acres) they could be traced to improper deforestation and pasturage.

3. While the forest could not have prevented such an extreme flood as that of 1882, yet, on the other hand, to the forest is due the fact that the Alb watershed experiences such disasters but rarely, more rarely even than adjoining valleys with a smaller proportion of forest area.

These facts tend, therefore, to show that while in the occurrence of floods, climate, character of soil, slope, and especially meteorological conditions play the most important part, the forest cover must also be considered a factor without which the floods would be greater and more destructive. It is evident, however, that forests alone can not be depended upon to prevent the occurrence of exceptional floods and that engineering works are necessary for the control of the flow of water in the rivers.

SUMMARY OF EFFECTS OF FORESTS UPON STREAM FLOW

The available observations upon the behavior of streams in this country and abroad have established the following facts:

1. The total discharge of large rivers depends upon climate, precipitation, and evaporation. The observed fluctuation in the total amount of water carried by rivers during a long period of years depends upon climatic cycles of wet and dry years.
2. The regularity of flow of rivers and streams throughout the year depends upon the storage capacity of the watershed, which feeds the stored water to the streams during the summer through underground seepage and by springs. In winter the rivers are fed directly by precipitation, which reaches them chiefly as surface run-off.
3. Among the factors, such as climate and character of the soil, which affect the storage capacity of a watershed, and therefore the regularity of stream flow, the forest plays an important part, especially on impermeable soils. The mean low stages as well as the moderately high stages in the rivers depend upon the extent of forest cover on the watersheds. The forest tends to equalize the flow throughout the year by making the low stages higher and the high stages lower.
4. Floods which are produced by exceptional meteorological conditions can not be prevented by forests, but without their mitigating influence the floods are more severe and destructive.

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SOIL EROSION A NATIONAL MENACE

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and

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Inspector of Grazing, Branch of Research,
Forest Service

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By H. H. Bennett, *Soil Scientist, Soil Investigations, Bureau of Chemistry and Soils*, and W. R. Chapline, *Inspector of Grazing, Branch of Research, Forest Service*

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PART 1. SOME ASPECTS OF THE WASTAGE CAUSED BY SOIL EROSION[1]

By H. H. Bennett

This circular is concerned chiefly with that part of erosion which exceeds the normal erosion taking place in varying degrees, usually at a slow rate, as the result of artificial disturbance of the vegetative cover and ground equilibrium chiefly through the instrumentality of man and his domestic animals. Removal of forest growth, grass and shrubs and breaking the ground surface by cultivation, the trampling of livestock, etc., accentuate erosion to a degree far beyond that taking place under average natural conditions, especially on those soils that are peculiarly susceptible to rainwash. This speeding up of the washing varies greatly from place to place, according to soil character, climatic conditions, vegetative cover, degree of slope, disturbance of the ground surface, and depletion of the absorptive organic matter in the soil under continuous clean cultivation. Under normal conditions rock decay keeps pace with soil removal in many places; under the artificial conditions referred to, soil removal by the rains exceeds the rate of natural soil formation over a vast area of cultivated lands and grazing lands, often working down to bedrock.

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[1] This part discusses only the evils of erosion by rainwash. Much damage is also done by wind erosion, but this phase of the problem is not treated here. The details of checking and preventing erosion and restoring to use the recoverable areas are not included, since that important side of the problem deserves a full paper in itself.

GENERAL STATEMENT

Not less than 126,000,000,000 pounds of plant-food material is removed from the fields and pastures of the United States every year. Most of this loss is from cultivated and abandoned fields and overgrazed pastures and ranges. The value of the plant-food elements (considering only phosphorus, potash, and nitrogen) in this waste, as estimated on the basis of the chemical analyses of 389 samples of surface soil, collected throughout the United States, and the recent selling prices of the cheapest forms of fertilizer materials containing these plant nutrients, exceeds $2,000,000,000 annually. Of this amount there is evidence to indicate that at least $200,000,000 can be charged up as a tangible yearly loss to the farmers of the Nation. These calculations do not take into account the losses of lime, magnesia, and sulphur.

In this connection it must be considered that rainwash removes not only the plant-food elements but also the soil itself. The plant-food elements removed by crops (the crops do not take away the soil, but extract nutrients from it) can be restored in the form of fertilizers, manures, and soil-improving crops turned under; but the soil that is washed out of fields can not be restored, except by those exceedingly slow natural processes of soil building that require, in many instances, centuries to develop a comparatively thin layer. It would be entirely impracticable to replace even a small part of the eroded matter, which might be recoverable from stranded material not yet swept into the rivers.

A very considerable part of the wastage of erosion is obviously an immediate loss to the farmer, who in countless instances is in no economic position to stand the loss. Much of the wastage that perhaps might not be classed as an immediate farm loss is nevertheless a loss to posterity, and there are indications that our increasing population may feel acutely the evil effects of this scourge of the land, now largely unrestrained. A considerable part of the erosional débris goes to clog stream channels, to cover fertile alluvium with comparatively infertile sand and other coarse materials assorted from flood water, and to cause productive stream bottoms to become swampy and much less valuable. When the mellow topsoil is gone with its valuable humus and nitrogen, less productive, less permeable, less absorptive, and more intractable material is exposed in its place. As a rule this exposed material is the "raw" subsoil, which must be loosened, aerated, and supplied with the needed humus to put it into the condition best suited to plant growth. This rebuilding of the surface soil requires time, work, and money. In most places, this exposed material is heavier than the original soil, is stiffer, more difficult to plow, less penetrable to plant roots, less absorptive of rainfall and less retentive of that which is absorbed, and apparently its plant-food elements frequently have not been converted into available plant nutrients to anything like the degree that obtains in the displaced surface soil. This comparative inertness of the freshly exposed material is comparable to the lessened productivity brought about in some soils by suddenly plowing large quantities of the subsoil material to the surface. Such raw material must be given more intensive tillage in order to unlock its contained plant food, and on much of it lime and organic manures will be needed in order to reduce its stiffness sufficiently to make it amenable to efficient cultivation, to the establishment of a desirable seed-bed tilth. It bakes easier and, as a consequence, crops growing on it are less resistant to dry seasons, because of rapid evaporation from the hardened surface, and the many cracks that form deep into the subsoil to enlarge the area exposed to direct evaporation. Crops also suffer more in wet seasons because the material becomes more soggy or water-logged than did the original soil. On much of it both fertilizer and lime will be required for satisfactory yields.

Certain piedmont areas whose records are known have, within a period of 30 years, lost their topsoil entirely, 10 inches or more of loam and clay loam having been washed off down to the clay subsoil; and on this clay subsoil, substituted for the departed soil, from 400 to 600 pounds of fertilizer are required to produce as much cotton per acre as formerly was grown with 200 to 250 pounds of fertilizer of no better quality.

While these difficulties of tillage and the lowered productivity are being attended to by the farmer in those fields not yet abandoned, the unprotected fields continue to wash. Unfortunately the farmers in many localities are doing little or nothing to stop the wastage and much to accentuate it. (Pl. 1, A.) In many instances the farmer does not know just what to do to slow down erosion. In many other cases he does not even suspect that the waning productivity of his fields results from any cause other than a natural reduction of the plant-food supply by the crops removed. He does not recognize the fact that gradual erosion, working unceasingly and more or less equally at all points, is the principal thief of the fertility of his soil until spots of subsoil clay or rock begin to appear over the sloping areas.

SOME WASTING AREAS

The southern part of the great Appalachian Valley is an admirable place to see the evil effects of that gradual land washing known as sheet erosion. Here in thousands of areas of formerly rich limestone soil of loam, silt loam, and clay loam texture, the topsoil has been removed. The numerous galls or clay exposures that now splotch the slopes lose their moisture quickly in dry weather. The damaging effects of drought upon crops are felt much quicker than formerly, according to those who have witnessed these changes in the soil. A much lighter rain than formerly now turns the Tennessee River red with wash from the red lands of its drainage basin. Added to the severe impoverishment of a tremendous area of land throughout this great valley, and its extensions southward into Georgia and Alabama and northward into Virginia, are the gullied areas, which are severely impaired or completely ruined by erosional ravines that finger out through numerous hill slopes and even many undulating valley areas. Field after field has been abandoned to brush, and the destruction continues.

Much erosion of the same type has taken place over the smoother uplands of south-central Kentucky; that is, in the rolling parts of the highland rim country; over much of the Piedmont region, and through many parts of the Appalachian Plateau. Land destruction of even worse types is to be seen in the great region of loessial soils that cover the uplands bordering the Mississippi and Missouri Rivers and many of their tributaries, from Baton Rouge, La., northward. Numerous areas, small and large, have been severely impoverished and even ruined in the famous black lands of Texas. Even the drier lands of the West and the comparatively smooth prairies and plains of the North-Central States have not escaped damage. Erosion is wasting the fertility of the soil and even the whole body of the soil in many places where the slope is sufficient for rain water to run downhill. There are some exceptions to this, or rather some partial exceptions, such as the nearly level lands, the loose, deep sandy lands, the highly absorptive gravelly areas, the loose glacial till and morainic deposits in parts of the northern border of the country, the peculiar red lands of the northern Pacific coastal region, and a few others. Although the total area of these more or less erosion-resistant soils is large, the area of those lands which are susceptible to washing and which are being washed in a wasteful way, more disastrously in some places than in others, is very much larger. Save when the fields are frozen or are covered with a blanket of hardened snow, erosion goes on upon these vulnerable lands during every rain that is sufficiently heavy to cause water to run downhill. Even the gentle spring rains cause some erosion, and the surface water flows away from sloping fields muddied red, yellow, or dun, according to the color of the soils of the neighborhood. This color is caused by soil materials started en route to the sea. Most of this material comes from the surface layer, the richest part of the soil.

FIGURES ON SOIL WASTAGE

The estimate of the quantity of plant-food elements annually lost by erosion, as given above, is a minimum estimate based upon a yearly discharge of 500,000,000 tons of suspended material into the sea by rivers,[2] plus twice this amount stranded upon lower slopes and deposited over flood plains, in the channels of streams, and even in the basins of reservoirs, where it is not needed and not wanted. Often this overwash does much more damage than good to the lands affected. It gradually reduces reservoir storage capacity and makes water-power plants dependent more and more upon the flow of the stream rather than upon the impounded water.

It is obvious to all who are familiar with field conditions that the amount of erosional débris in transit to the sea, but temporarily stranded on the way, each year very greatly exceeds twice the amount that actually passes out the mouths of rivers into tidewater. Some soil scientists believe the amount thus annually washed out of the fields and pastures and lodged on the way to the oceans is more than a hundred times greater than that actually entering the sea. The figure used above has been used merely because no satisfactory data upon which to base conclusively accurate estimates are available.

The estimates given do not include the dissolved matter which is annually discharged to the sea, a very considerable part of which obviously comes from erosional products. Furthermore, it is not known how much erosional detritus enters the ocean as drag material swept along the bottoms of streams. This material is exceedingly difficult to measure. The débris thus swept along the bottoms of many streams travels rather after the manner of waves or of sand dunes drifting before the wind. This characteristic of many river beds was brought out before a commissioner appointed by the Supreme Court of the United States in the expert testimony relating to the recent Red River boundary dispute between Texas and Oklahoma. Gilbert (*9, p. 11*) makes the following interesting observations regarding the process:

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[2] Dole and Stabler have estimated that 518,000,000 tons of suspended matter and 270,000,000 tons of dissolved matter are transported to tidewater every year by the streams of the United States (*6, p. 83*).[3] T. C. Chamberlin estimates that 1,000,000.000 or more tons of "richest soil matter" are washed into the oceans from the lands of this country every year (5).

[3] Italic figures in parentheses refer to "Literature cited," p. 35.

> Some particles of the bed load slide; many roll; the multitude make short skips or leaps, the process being called saltation. Saltation grades into suspension.
>
> When the conditions are such that the bed load is small, the bed is molded into hills, called dunes, which travel downstream. Their mode of advance is like that of eolian dunes, the current eroding their upstream faces and depositing the eroded material on the downstream faces. With any progressive change of conditions tending to increase the load, the dunes eventually disappear and the débris surface becomes smooth. The smooth phase is in turn succeeded by a second rhythmic phase, in which a system of hills travel upstream. These are called antidunes, and their movement is accomplished by erosion on the downstream face and deposition on the upstream face. Both rhythms of débris movement are initiated by rhythms of water movement.

The amount of plant food in this minimum estimate of soil wastage by erosion (1,500,000,000 tons of solid matter annually) amounts to about 126,000,000,000 pounds, on the basis of the average compositions of the soils of the country as computed from chemical analyses of 389 samples of surface soil collected by the Bureau of Soils (1.55 per cent potash, 0.15 per cent phosphoric acid, 0.10 per cent nitrogen, 1.56 per cent lime, and 0.84 per cent magnesia). This is more than twenty-one times the annual net loss due to crops removed (5,900,000,000 pounds, according to the National Industrial Conference Board) (*16*). The amount of phosphoric acid, nitrogen, and potash alone in this annually removed soil material equals 54,000,000,000 pounds. Not all of this wasted plant food is immediately available, of course; but it comes principally from the soil layer, the main feeding reservoir of plants, and for this and for other reasons it is justifiable, doubtless, to consider the bulk of it as essentially representing lost plant food, without any quibbling about part of it having potential value only.

By catching and measuring the run-off and wash-off from a 3.68 per cent slope at the Missouri Agricultural Experiment Station, on the watershed of the Missouri River, it was found that for an average of six years 41.2 tons of soil material were annually washed from 1 acre of land plowed 4 inches deep, and that 68.73 per cent of the rainfall, the total precipitation amounting to 35.87 inches a year, was held back; that is, 24.65 inches of the 35.87 inches of precipitation were temporarily absorbed as an average for the six-year period. From a grass-covered area of the same slope and soil type less than 0.3 ton of solid matter was removed each year (or a total of 1.7 tons in six years), while 88.45 per cent of the rainfall was retained.

In 24 years this rate of erosion would result in the removal of a 7-inch layer of soil from the area tilled 4 inches deep; but for the removal of the same thickness of soil from the grassed area 3,547 years would be required.

At the Spur substation of the Texas Agricultural Experiment Station,[4] in the subhumid part of west Texas, 40.7 tons per acre of soil material were removed from a 2 per cent slope of fallow land by approximately 27 inches of rainfall. Of this precipitation only 55 per cent was retained (at least temporarily) on cultivated bare land of the same soil and slope without terracing, whereas 84 per cent was retained on an area covered with Buffalo grass.

The erosion station[5] in the piedmont region of North Carolina measured from an uncultivated plot a loss of 24.9 tons of solid matter to the acre each year, when the rainfall was only 35.6 inches, as against a normal of 43.9 inches. On the same slope and soil the erosion from grassland that year amounted to only 0.06 ton to the acre. In other words, the grass held back four hundred and fifteen times as much surface soil as was retained on untilled bare ground. It held back two hundred and fifteen times as much soil as was retained in the cotton plots on the same soil, having the same degree of slope. The uncultivated plot retained 64.5 per cent of the rainfall, the cotton plot 74.4 per cent, and grassland 98.5 per cent.

The agricultural scientists at the Missouri Agricultural Experiment Station have this to say of erosion (*7*):

> Most of the worn-out lands of the world are in their present condition because much of the surface soil has washed away, and not because they have been worn out by cropping. Productive soils can be maintained through centuries of farming if serious erosion is prevented. The soils of Missouri have become gradually less fertile during the last one hundred years due in large measure to the excessive cultivation of rolling lands. Many of the most fertile soils in the rolling prairies and timber lands of this state have been kept in corn until the "clay spots" are evident on nearly every hillside. So much soil has been lost from even the more gently rolling parts of the fields that the yields are far below those obtained by our grandfathers who brought the land into cultivation. The erosion of cultivated fields is taking place at such a rate that it is calling for a decided change in our system of soil management. If we are to maintain our acre-yields at a point where crops can be produced at a profit we must make every reasonable effort to reduce the amount of soil fertility that is carried away during heavy rains.
>
> Approximately three-fourths of the area of Missouri is subject to more or less serious erosion. The map . . . shows where these soils are to be found. It will be seen from this map that erosion is serious on many of the most fertile soils of the state. This is particularly true in the rich rolling prairie regions of central and northwest Missouri, where owing to the fertility of these soils much of the land is kept in corn a large part of the time. It must be remembered that not all the soils . . . erode at the same rate . . . in the Ozark region, they [the soils] are largely covered with timber so that erosion cannot be considered a serious problem.

A single county in the southern part of the piedmont region was found by actual survey (*4*) to contain 90,000 acres of land, largely cultivated at one time, which has been permanently ruined by erosion. The whole area has been dissected by gullies, and bedrock is exposed in thousands of places. Here and there islands and peninsulas of arable land have been left between hideous gullies, but most of these remnants are too small to cultivate. The land has been so devastated that it can not be reclaimed to cultivation until centuries of rock decay have restored the soil. It has some value, however, for

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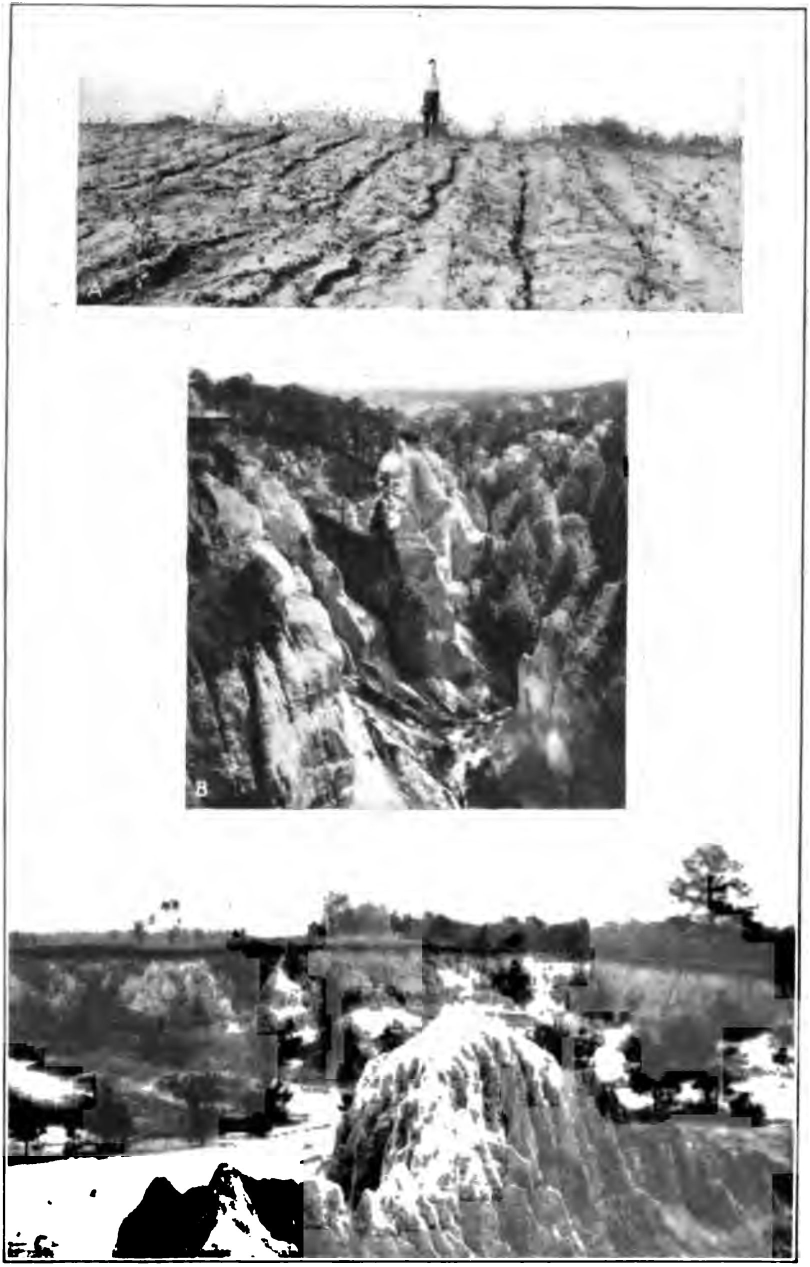
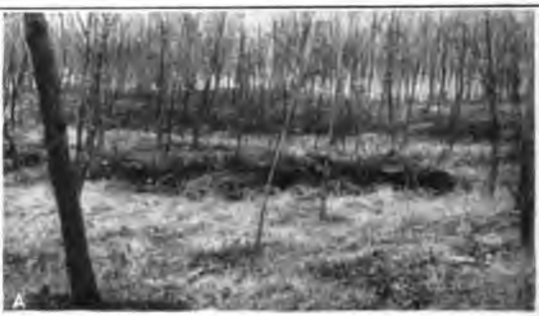
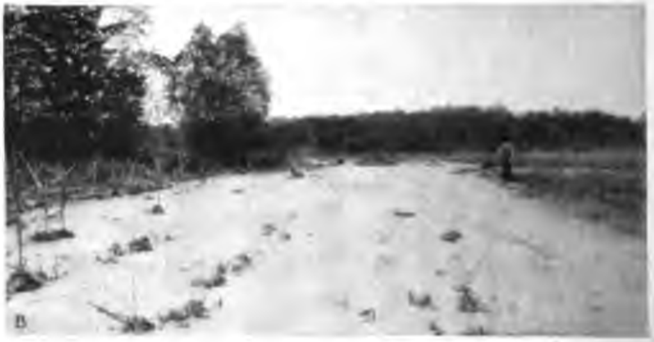
[4] Preliminary figures furnished by officials of the Texas Agricultural Experiment Station.

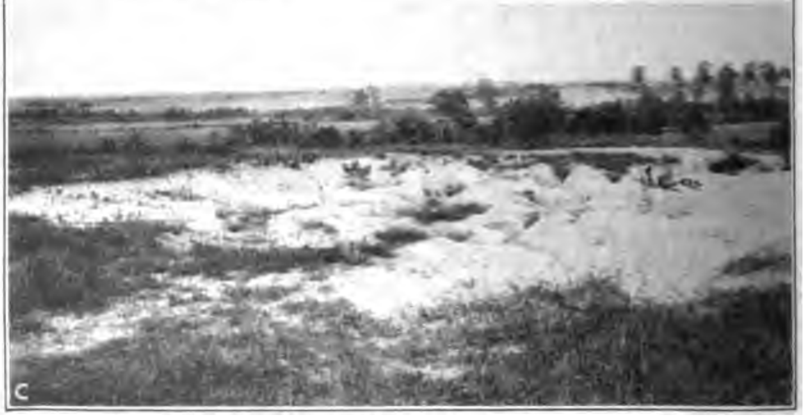
[5] BARTEL, F. O. SECOND PROGRESS REPORT, SOIL-EROSION EXPERIMENTS, EXPERIMENT STATION FARM, RALEIGH, N. C. (A project of the Div. Agr. Engin., Bur. Public Roads, in cooperation with the N. C. Dept. Agr.)



A.—Cotton field showing the early development of destructive gullies in the middles of rows extending up and down the slope
B.—Result of uncontrolled erosion on Greenville fine sandy loam
C.—Deep erosion of the lateral extension type in the loessial region of the lower Mississippi Valley



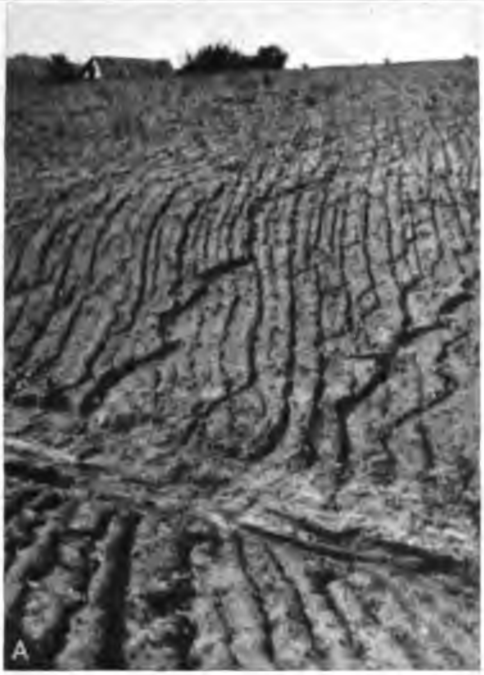


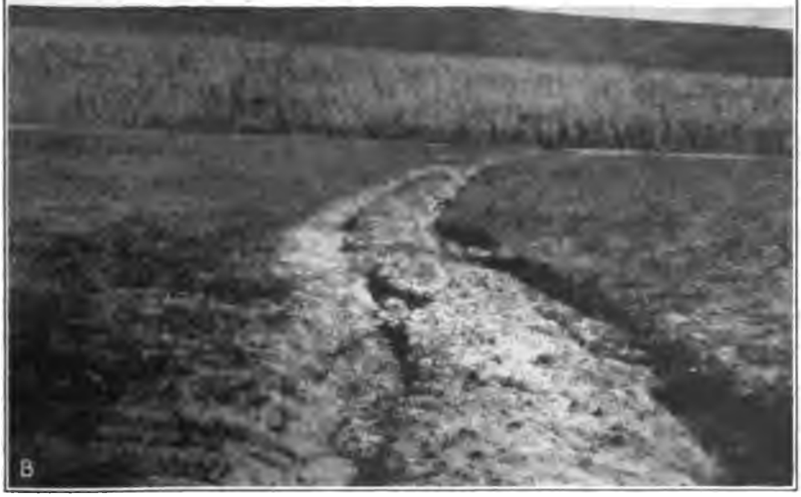


A.—Six-year-old locust trees which have not only arrested washing on what was once a rather severely eroded area in western Tennessee but are also assisting in a gradual improvement of the soil

B.—A cornfield almost obliterated by a blanket of infertile sand assorted and deposited by erosional waters of one heavy rain

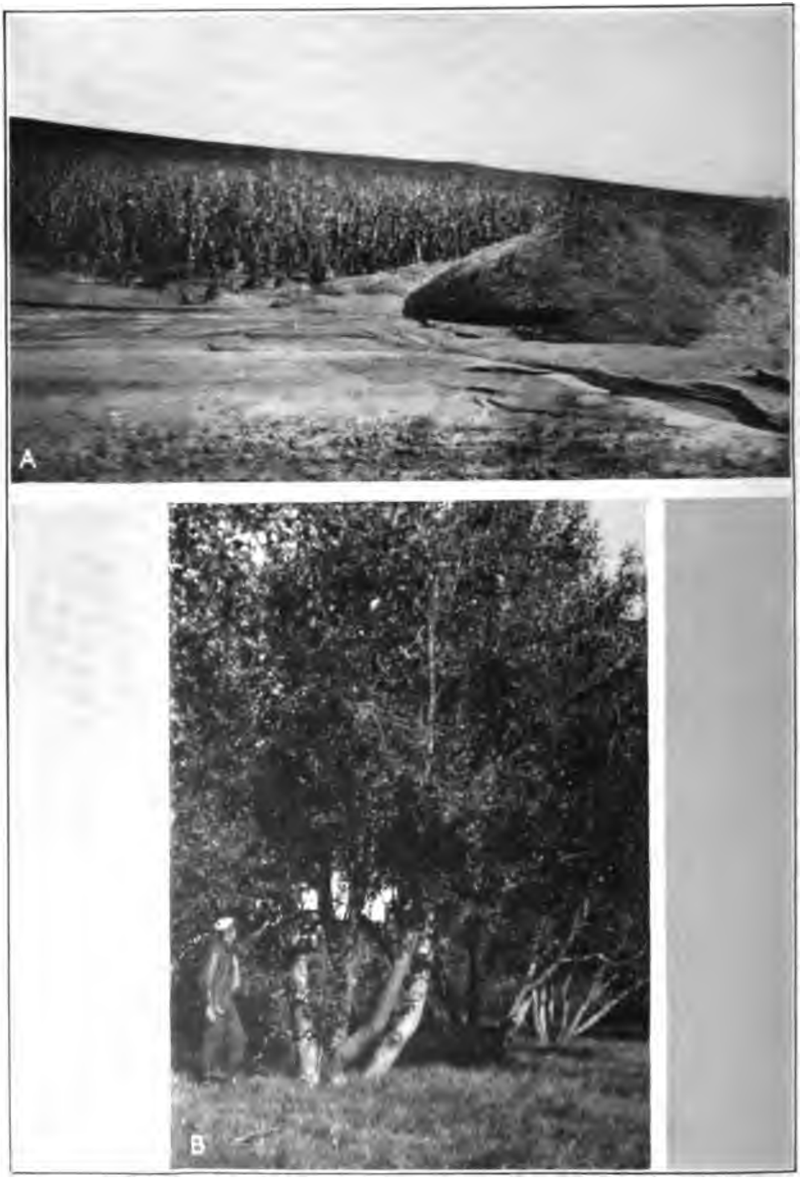
C.—Typical erosion on dark Houston clay of the Alabama-Mississippi prairie region





A.—A field in northeastern Kansas, about 12 miles from Missouri River, that was eroded during a single rainy spell

B.—Highly productive Knox silt loam in northeastern Kansas, about 12 miles from Missouri River, severely damaged by incipient gullies, already 12 or 14 inches deep, which had their beginning in wheel tracks of the grain drill. This is the result of a single rainy period, after grain had been sown, fall of 1927. These will probably grow into deep gullies



A.—Stack of wheat straw dumped in gully in field of Marshall silt loam, which during the fall rains of one year caught and held 430 tons of rich soil material washed from adjacent slopes
B.—An apple orchard in the region of loessial soils, in northeastern Kansas. The trunks of the trees and some of the branches have been buried by soil washed from the adjacent uplands, the surface having been raised about 5 feet

growing shortleaf pine and for pasture. The extent of this devastated region unfortunately is yearly growing larger.

Another county in the Atlantic Coastal Plain (*12*) has 70,000 acres of former good farm soil, which, since clearing and cultivation, has been gullied beyond repair. In one place where a schoolhouse stood 40 years ago gullies having a depth of 100 feet or more are now found, and these finger through hundreds of acres of land, whose reclamation would baffle human ingenuity. (Pl. 1.)

The most severely eroded parts of this county are described as follows:

> The Rough gullied land includes areas which, as the result of erosion, are so steep and broken as to be unfit for agriculture. Much of the land classified under this head supports forest. Some areas are available for pasture, but a considerable total area is not even suitable for this use, as there are many deep gullies with steep or perpendicular sides on which no vegetation can find a footing. Providence and Trotman "Caves" . . . are examples of such areas. . . .
>
> In the southwestern part of the county in the Patterson Hills and in another large area . . . southwest of Spring Hill Church, a somewhat different condition is encountered. Here the Rough gullied land consists of narrow-topped ridges with precipitous slopes, covered with ferruginous sandstone fragments. No level land is found here and the slopes are generally too steep even to afford good pasture. . . . One of the largest [caves] within the county has developed in the memory of the present generation, having started with the formation of a small gully from the run-off of a barn. The caves, some of which are about 100 feet in depth and from 200 to 500 feet in width, ramify over large areas. There is little possibility of this gullied land being restored to a condition favorable to cultivation.

In the "brown loam" belt skirting the Mississippi bottoms on the east side, county after county includes 10,000, 20,000, or 30,000 acres of land which have been ruined by erosion. (Pl. 1.) Agriculture has been driven out of a very large part of the upland of several counties in northwestern Mississippi by the gullied condition of the upland. Hundreds of farms in these and many other counties of the region have been abandoned to timber and brush. Unfortunately, the kind of timber that has established itself over much of these dissected areas is largely worthless blackjack oak, simply because pine seed have not been distributed to start valuable pine forests or because black locusts have not been planted.[6] (Pl. 2, A.)

Not only have the uplands been widely and disastrously dissected, but large areas of former good alluvial land have been buried beneath infertile sands washed out of those upland gullies (pl. 2, B) which have cut down through the soil strata into Tertiary deposits beneath. Stream channels have been choked with erosional débris, and overflows have become so common that large tracts of highly productive soil formerly tilled are now nothing more than swamp land.

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[6] In this connection W. R. Mattoon, of the United States Forest Service, says: "The State of Tennessee through its Division of Forestry has aided several hundred farmers and public organizations, particularly in west Tennessee, in checking gully erosion by the planting of black locust. This work has been done on a gradually increasing scale since its inception, about 1913. Practical methods have been developed of planting one-year-old locust seedlings, spaced about six feet apart each way, over the entire wash or gullied area. Preparatory to planting, the gully banks are plowed off and brush dams built across the channels at strategic points to catch the soil. The black locust produces a heavy surface root system adapted to holding the soil, it is a legume and enriches the soil, it is a vigorous grower and endures thin soils, and it ranks as the second most lasting fence-post timber in this country. Black walnut, yellow poplar, pines, and other trees have also been planted. In addition to checking erosion the land is put to profitable use by growing valuable fence posts and other timber crops and the blue grass that invariably comes in supports limited grasing. A large number of farmers by this method have realized excellent money returns from old gullied lands."

The stream bottoms throughout the piedmont region from Virginia southward into east-central Alabama have been impaired by this process of overwash to an even greater extent. Here, probably, considerably more than 50 per cent of the bottom land has been converted into a nonarable swampy waste, entirely as the result of deposition of eroded material. In spite of the terracing that has long been practiced on many farms in the southern piedmont region, wastage of good agricultural uplands has gone on at a distressing rate, because many fields were not terraced and many terraces were not maintained. Thus, unleashed erosional waters, performing in the dual rôle of cutting away the topsoil of the uplands and depositing the less fertile assorted constituents of the eroded matter over the stream bottoms, have brought about an enormous amount of land impairment and destruction.

Some streams formerly navigable have been so choked with sand and mud, purely as a result of erosion, that they have not been plied by boats for a generation or more. E. N. Lowe, of the Mississippi Geological Survey, speaking of soil erosion and flood control in the Yazoo drainage basin, said five years ago (*13*):

> In many of our northern uplands [Mississippi] washing of the soil is progressing so rapidly without let or hindrance over large areas, that some necessary measures must be adopted soon to arrest the process, otherwise vast areas of formerly agricultural land will become hopeless wastes. Large areas in at least a dozen upland counties of north-central Mississippi have already reached such a condition of soil depletion that they are now hardly suitable for any kind of agriculture, and their taxable values are reduced accordingly.
>
> The erosion of these uplands has resulted not only in enormous losses of valuable agricultural soils, but also in concomitant stream-filling throughout those areas. Volumes of silt and sand after every heavy shower are poured into the streams from every furrow, gully and rill that trenches the hillsides, resulting in filling of their channels. The obliteration of their channels causes overflow of the streams after any considerable rain, with deposition of sand over valuable bottom lands, often doing irreparable damage.
>
> For years rapid and destructive filling has affected the Coldwater. Forty years ago boats of large size came up the river to Coldwater to load cotton. Now no kind of a boat can come up Coldwater River, so choked is it with sand bars.
>
> The Tallahatchie was formerly a navigable stream. Even as late as 1900 a small steamer drawing four feet of water plied on the Tallahatchie from Batesville downstream. Now the stream is choked with sand bars, and can be easily waded at almost any place.

In the great cotton-producing section of central Texas, known as the black waxy belt, white spots representing exposures of the basal chalk and marl beds that gave rise to the immensely productive black soil of this region, dot the landscape of the rolling areas. The same thing is to be seen in many parts of the Alabama-Mississippi prairie belt. (Pl. 2, C.) These exposures represent the products of erosion—nonarable land that has been substituted for some of the most productive cotton soil of the world. In one county of this region (*8*) 13.5 per cent of the total area was recently mapped as an eroded phase of the valuable Houston clay soil. It was found that much of this had been too severely washed to allow cultivation, whereas the remaining better parts become highly desiccated in dry seasons, giving lighter and lighter yields as the wearing off of the soil progresses.

SOIL EROSION NOT RESTRICTED TO THE SOUTH

The experts who recently completed the soil survey of Doniphan County, in northeastern Kansas, found that an average of at least 6 inches of soil had been removed from the rich uplands of the county. Nearly all tilled slopes have suffered, some much more severely than others because of variations in the surface relief and in the kind of soil. In one place examined an area of original timber had throughout its extent from 12 to 24 inches of rich soil overlying clay subsoil. This surface layer was so rich in humus, so moist and mellow, that it was possible to dig down through the dark-colored permeable soil with the bare hand, even to the depth of the subsoil. Cultivated soil of the same kind, having the same degree of slope, lying in immediate contact with this forested area had in most places no topsoil at all, as the result of erosion, and in some places even the exposed subsoil clay had been eroded off to a depth of 6 inches or more. Indeed, both soil and subsoil, it was found, had been washed off some areas down to the basal limestone that at one time was 4 feet beneath the surface.

These severe effects of erosion were found as a very common condition in a broad belt over the more rolling lands near the Missouri River; indeed, this condition, or a close approximation of it, was found to be the rule, not the exception, through this more rolling belt, where the virgin soil, the Knox and Marshall silt loams, were among the very richest upland soils in the United States. Apple trees were dying on the eroded hilltops where, seemingly, the soil moisture conditions had been unfavorably upset by the removal of the surface soil layer. In the depressions and on the gentler parts of the slopes and the bench positions some of the rich soil from above had lodged. In these places the apple trees were thriving. A farmer in this section said to the soil specialists:

> We have good apples on the deep soil of the flat places, but we have always had good apples in these places. These places did not need any more soil, they were already deep and rich. We want our soil to stay in the orchards and fields, but it is not staying there. In places 4 feet of soil has been washed off the land. The surface of the ground about our house has been gradually lowered more than a foot. I will show you washed places where not even weeds succeeded this year.

This terrific washing of the land has taken place in the memory of men living in the community. The wasted areas adjacent to the forested land referred to above were cleared about 40 years ago, according to the statements of men in the locality who said they had taken part in the clearing.

Wheat, alfalfa, and sweet-clover fields seeded in the fall of 1927 had been severely damaged by the fall rains. (Pl. 3, A.) In places each depression made by the seed drills had been converted into a small rill way or gully, and the wheel tracks of the seeder in some places had grown into ditches (pl. 3, B), which surely will expand rapidly into formidable gullies that will cause eventual abandonment of the areas affected. In small grain, alfalfa, and sweet-clover fields soil in excess of five tons to the acre was swept from the surface of numerous fields on these splendid soils, the Marshall and Knox silt loams, during a single period of rain last fall. In some fields of steeper slope the loss per acre as a result of this single rainy spell was estimated as amounting to fully 40 tons. Much of this erosional débris passed down from the upland slopes into depressions and stream ways to be carried off in flood waters, although large quantities, as was readily determined, were deposited locally over depressional flats and the flood plains of small and large streams, where none of it was needed. In one place a few miles south of Troy, Kans., where newly planted grainfields had been severely dissected by the fall rains of last year a farmer had left a series of wheat-straw stacks in a depression at the foot of converging slopes. Against the upper side of these large quantities of rich silt had lodged, building up small flood plains, or alluvial fans, 4 feet deep in places. (Pl. 4, A.) One of these stacks had caught 430 tons of this rich soil matter during the single short rainy period referred to, even where vast quantities had been swept by to lower levels after the catchment basin formed by the straw bulwark had been filled. These straw stacks represented the sole attempt to check soil erosion that was observed through several Missouri and Kansas counties bordering on the Missouri River.

Along the outer edge of the Missouri River bottoms, in the northern part of Doniphan County, a farmer had constructed an 8-foot embankment some distance out in the bottoms, approximately parallel to the foot of the upland, in order to intercept soil material that was being brought out of the hills by small local streams. This erosional material was covering the farmer's rich Missouri River alluvium (Wabash and Sarpy soils), causing a reduction in the yield of corn, and was continually washing over the roadways, rendering them impassable. Within 10 years eroded material from the uplands had lodged here level with the dikes, from 5 to 7 feet deep. Thus had been formed a terrace averaging 6 feet deep over 40 acres; and the intercepted soil was not so productive as the land it had buried. The weight of this erosional placed material amounted to about 480,000 tons. It had accumulated at the approximate rate of 1,200 tons to the acre each year. It should be observed in this connection that not all of the erosional detritus brought out of the uplands had been held by the dike. At first, part of it had escaped downstream in the conveying flood waters. Finally drainage had been blocked in that direction, whereupon the material began to escape in the transporting water around the upstream end of the diked area.

This sort of thing is taking place in varying degrees up and down the Missouri River and its tributaries, and along many other streams of the central West. Recently, it was necessary for the soil surveyors working in this great region to recognize a new soil type in order to classify and map material derived from the regional uplands by erosion and freshly deposited over older stream alluvium.

In an apple orchard near Lookout Mountain in northeastern Kansas the trunks of the trees had been completely buried by overwash of silt from the adjacent uplands, and the level of the ground was among the branches of the trees. (Pl. 4, B.) The owner of this orchard stated that although the apple trees had not seemed to suffer by the filling in, the uplands had suffered very greatly from the gradual erosion that gave rise to the transported soil.

Near this orchard a gully is now advancing at a minimum rate of 150 feet a year, according to local information. This ravine is

60 or 75 feet deep, nearly 300 feet wide in places and almost three-fourths of a mile long. It is destined to destroy all the farm land in this fertile valley, including the apple orchard, and it may, with its deploying prongs, cut through the local hills.

Already in this new agricultural region fields (pl. 5, A) and even farms are beginning to be abandoned in the more rolling belts near the river, and land is being rapidly impoverished many miles back from the river. Indeed, all cultivated slopes are suffering to some extent. Nothing is being done to slow down the wastage, but considerable to accentuate it. In general, no effort is being made to cultivate along the slope contours; corn rows are run straight up and down hills as often as otherwise. It is a common practice in this region to plow furrows down the slopes in the spring, in order to allow water standing temporarily in corn "middles" to flow out. These furrows commonly develop into gullies that soon grow beyond control at anything like reasonable cost.

There are no terraces in this region; the farmers do not even know what they are. Erosion is gathering momentum. As the more absorptive topsoil is washed off down to the less absorptive subsoil, the rate of wastage increases. So, this region, which has already suffered seriously from rainwash, is really just upon the threshold of the most impoverishing kind of erosional wastage, and nothing is being done to conserve these splendid agricultural lands, the capital of the farmers living on them and a vital heritage to posterity.

It is not to be understood from the above that erosion in the north-central part of the United States is restricted to the Missouri River region. The wastage is taking place generally throughout this great region, most violently, of course, on the sloping areas. Soil displacement by this process is slow on the very extensive flat areas of the prairie regions that formerly were covered by a most efficient soil-conserving mat of native grass; but even here there is a much greater gradual removal of the rich surface material than is commonly recognized. (Pl. 5, B.) Since the clearing of the sloping and rolling areas and the destruction of the virgin sod, much costly washing has taken place in Missouri, Iowa, Nebraska, Illinois, Indiana, Ohio, Wisconsin, and other States. Recent soil surveys in southwestern Wisconsin have shown that the problem of erosion is a most serious one in many localities. It was found that slopes, especially on the Clinton and Boone soils, which were originally timbered or covered with brush, have been seriously gullied and damaged by sheet erosion from rain water and melting snow. Gullying was found even on bench lands of the valleys (Bertrand soils), and here as elsewhere the stream bottoms were being covered by overwash. These latter instances are mentioned to show that soil wash is a land menace even in parts of the northern border States.

EROSION IN THE DRIER REGIONS

Under the light rainfall of the western dry regions one might reasonably conclude, in the absence of the facts, that erosion is of negligible importance in comparison with that taking place in the humid regions. From the viewpoint of the extent of erosion, such a conclusion would be entirely contrary to the facts, at least for very large areas. The rivers entering the Mississippi from the west carry very large amounts of suspended matter. Some have ascribed this to the treeless condition of the western region. Doubtless this is a contributing factor; and certainly the vast extent of land used for clean-cultivated crops in the prairies and in the more humid eastern part of the Plains, is a most important factor. The peculiar structural behavior of the soils in the regions west of the prairies and eastern plain border, near the headwaters of the streams flowing eastward, coupled with the frequent dashing character of the rainfall, is also an important contributing factor to the heavily silted condition of these streams.

Much of the soil of the dry regions upon desiccation assumes a fluffy loosened condition or structure, to a depth of several inches. The structure is so loose, that the naturally pulverized surface material, even of heavy clays, can be scooped up freely with the hand. Heavy downpours cause this chafflike material to be swept ahead of the flowing water until the soil particles have become thoroughly saturated, disintegrated, and finally coalesced to form an emulsion which might appropriately be styled " liquefied " soil. The flow of this is at first slow, but it speeds up as the emulsion becomes thinner with the increasing proportion of water from rainfall.

In the cattle country of the southwestern dry region numerous places were observed and studied last year (1927), where the richest soil of the region, the areas of deeply accumulated valley-filling material (such as the Reeves silty clay loam), had been washed out entirely from valleys that formerly afforded excellent grazing. (Pl. 5, C.) This process was seen in all stages of development. The washes have their beginning in those places where the natural vegetative cover and normal ground equilibrium have been seriously disturbed. (Pl. 6, A.) Most of them have their start in cattle trails and the wheel ruts in roads. (Pl. 6, B.) In one place near Fort Davis, Tex., an area of approximately 1,000 acres had been so riddled by gullies, which had their beginning in a prairie dog town, that the ground, although once excellent grassland, was almost bare of vegetation. In another locality a gully 30 feet deep, 200 feet wide, and nearly a mile long was seen in the place of a former main highway. This gully was still growing, more rapidly than ever, acording to the ranchman who owned the land.

It was observed in this general region that many of the highways are protected from lateral erosion by retard and diversion dikes, and by diversion ditches dug along the slopes above the roadbed. This form of protection has been successful in some places, but not in others, the difference being due to soil variation and difference in adjustment of the ditch grade to the slope. On some soils of high vulnerability to rainwash, these ditches, built to protect the roadbed, have grown into erosional gullies, which have extended so far that the road has been undermined, necessitating its relocation.

The gullies that cut to pieces the valuable valley grazing lands of this dry country usually go down as incisions having perpendicular walls. When the gullies are cut to the underlying gravel or soft material, an undermining process begins that causes huge blocks of the upper strata to cave into the trenches. These blocks melt away rapidly with subsequent floods. In this region a peculiar soil property serves to accentuate erosion on some very extensive and valuable soil types. The clay soil, when it becomes dry, cracks and scales off from the sides of erosional trenches in such a way as to cause one gully to cut through to another. Thus, numerous natural bridges and caves are formed, and these help to speed up the invasion and destruction of the land.

A ranchman near Marfa, Tex., 15 years ago found that an important strip of his valley grazing land was in danger of being destroyed by an enlarging arroyo. To avoid disaster, he threw a small dam from one side of the valley out across the wash, and about halfway across the floor of the valley; from the end of this a wing dam was turned down the valley and carried for a long distance parallel to the arroyo. The result has been that the arroyo has nearly filled in, both above and below the dam, and the increased water carried over that part of the valley floor lying between the wing dam and the foot of the upland has caused greater subsoil storage of moisture, and thereby made the grazing value of the area affected 15 times as great as it was, according to the statement of the rancher. In addition, the alluvial soil, thus enriched in subsoil moisture has produced valuable crops of feed without irrigation, which in this region is very costly.

In parts of the western deserts railroad companies have found it necessary to construct numerous retard and diversion embankments along their road fills to prevent lateral erosion. The Southern Pacific Railroad in the desert between Niland, Calif., and the Colorado River, for example, has protected sections of its roadbed from erosion by a system of A-shaped embankments that catch the water on the upper side of the track and divert it or concentrate it to soundly constructed culverts beneath the track. Thus, a continuous line of earthen embankments connected like a rail fence, has been built to ward off the abrasive effects of silt and sand-laden desert flood water, and this line at no small cost, must be kept in repair against the erosion of the rainy seasons.

Recently, as the writer was informed, a brief heavy rainy spell (11 inches in three days) in the southwestern part of the United States caused deposition of a layer of infertile sandy material over a valuable orange grove. The trees quickly began to show signs of serious injury, and it was necessary to do something about it. It is said to have cost in the neighborhood of $100,000 to haul the deeper deposits of this inert material (that varying from 1 to 2 feet in depth) out of the grove, and to rake back the shallower deposits from the base of the trees.

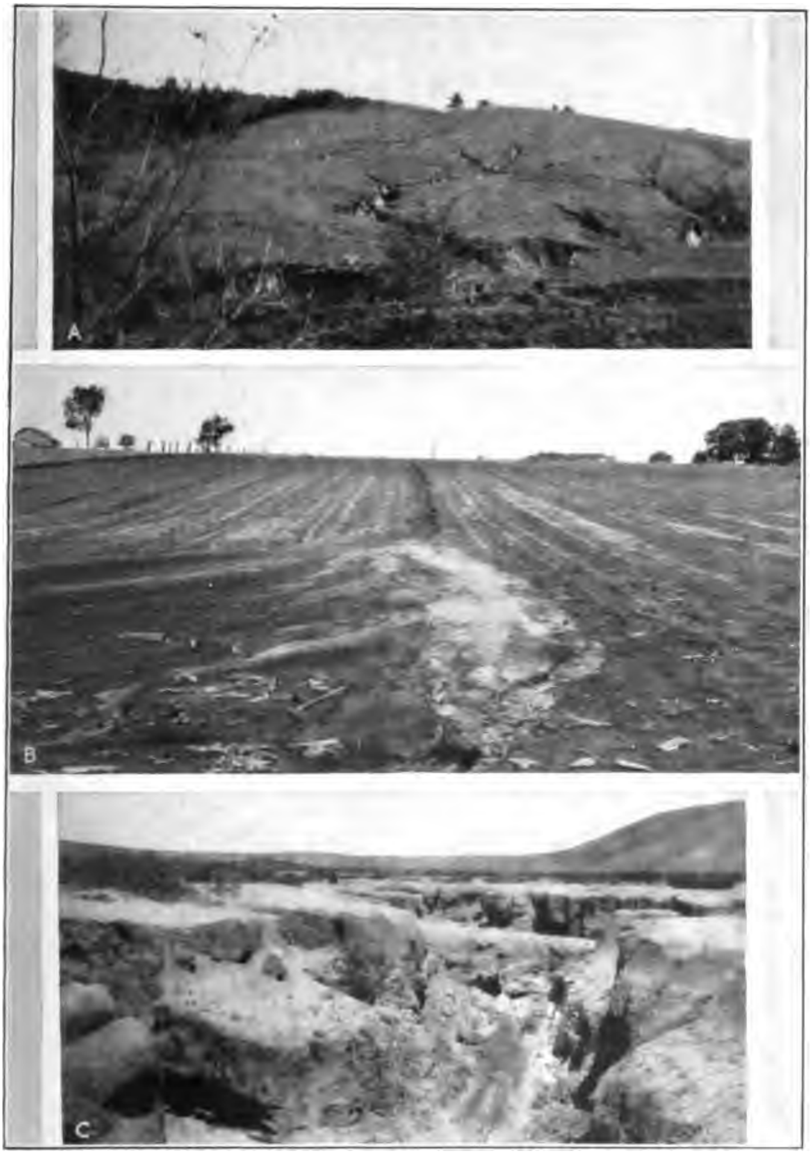
In orchards observed by the writer last year (1927) in the valley east of Santa Paula, Calif., fruit trees had been planted on well-constructed terraces to prevent erosion, and, in addition, diversion ditches had been dug along the upper side to catch and divert injurious erosional débris coming out of the adjacent shale hills. To protect the diversion ditch itself, eucalyptus and tamarisk trees had been planted, not only along the ditch embankment, but along the hill slopes above the ditch.

RELATION OF SEDIMENTS TO FERTILITY

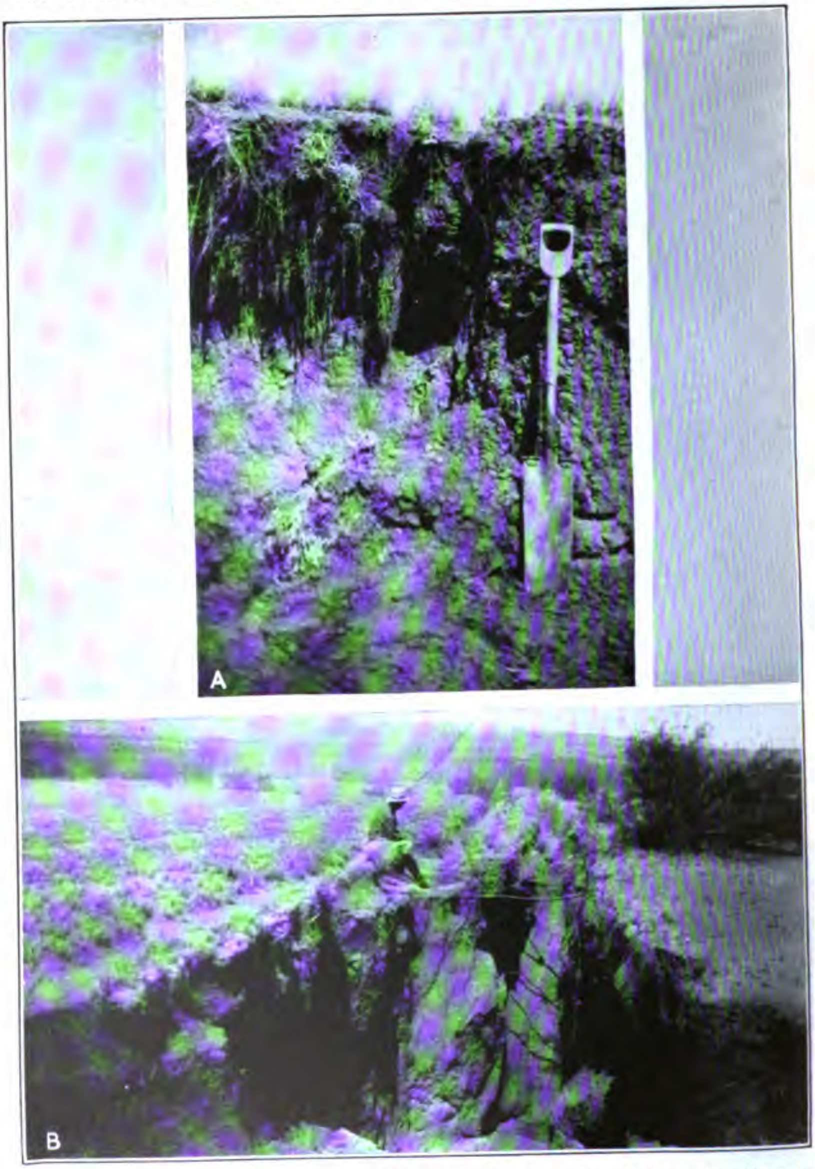
It is commonly believed that the products of erosion which do not actually go out to sea are not being wasted. It is believed that frequent deposition of flood alluvium enriches the land, and that floods, therefore, are beneficial, in respect to the productivity of the overflowed alluvial plains. There is some truth in this, of course; but in the main the conception is incorrect, and frequently the good accomplished is greatly overestimated. It has already been pointed out how disastrous overwash of inert sand has been to the alluvial lands of the piedmont region and the "brown loam" belt of the lower Mississippi Valley. This same condition, or an approximation of it, applies also to many other parts of the country. In the Ozark region, for example, the bottom lands of many farms, on which there was but little arable soil in the beginning, aside from the bottoms, have been seriously impaired or ruined by overwash of chert gravel washed down from the regional hillsides. The November flood of 1927 in the New England States laid down upon many of the productive bottom lands a blanket of relatively infertile loose sand and gravel, burying meadows and fields. In other parts of the bottoms the soil was ripped out and washed away by the swift, deep flood water.

The beneficial effects of the sediments deposited by the spring floods of the River Nile are often cited. It is not known precisely what the benefit amounts to in terms of money; but there is no doubt that some measure of soil enrichment does follow the floods of that river. It is obvious, also, that some enrichment of the soil is derived from the finer sediments laid down by the flood waters of the Mississippi. However, some damage is occasioned by the deposits of comparatively inert coarse sand scattered about in the "sand blows," or by patchy deposits that take form locally with every flood spreading over that great delta region. However, the damage and destruction to property and planted crops occasioned by the Mississippi floods quite obviously very greatly exceeds the net benefits accruing from sedimentation. When one thinks of possible benefits to alluvial land derived from deposition of flood-water silt, one should not lose sight of the damage done to upstream farm lands by the removal of the silt into the streams. Also the resultant increase in flood volume due to the additions of solid and dissolved products of erosion is dangerous, and one should not overlook the increased rapidity with which rain water flows off those areas denuded of their more absorptive topsoil. The alluvial soils of the flood plain of the Mississippi and most of its tributaries are naturally so rich that most of them could be cropped probably for many generations, without severe impoverishment of the soil. These alluvial soils are deep, many of them very deep, and exceptionally rich in plant food. The average chemical composition of "buckshot" soil samples taken from Coahoma and Issaquena Counties, Miss., is as follows (*3*): 0.28 per cent phosphoric acid; 0.80 per cent potash; 0.81 per cent lime; 1.31 per cent magnesia.

The phosphorus content of this soil, which is by far the most extensive soil of the lower Mississippi flood plain, is nearly twice that of the average surface soil of the country. It also exceeds the average soil considerably in content of organic matter and nitrogen. Material of this exceptionally good fertility extends to a depth of several feet with but slight change. The condition of fertility is so good that new sediments are not particularly needed, although,

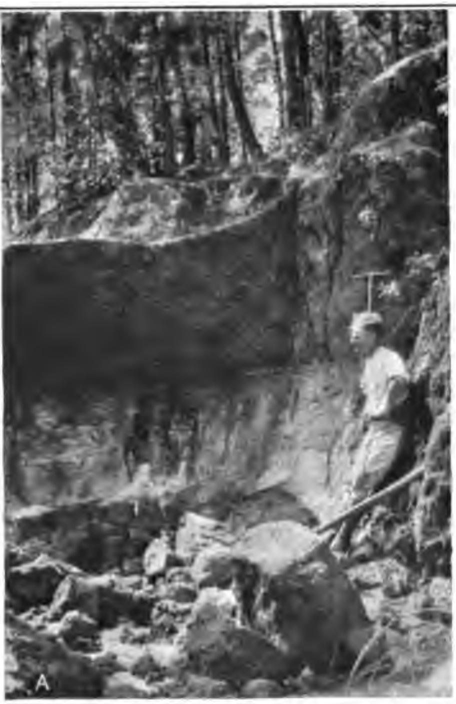


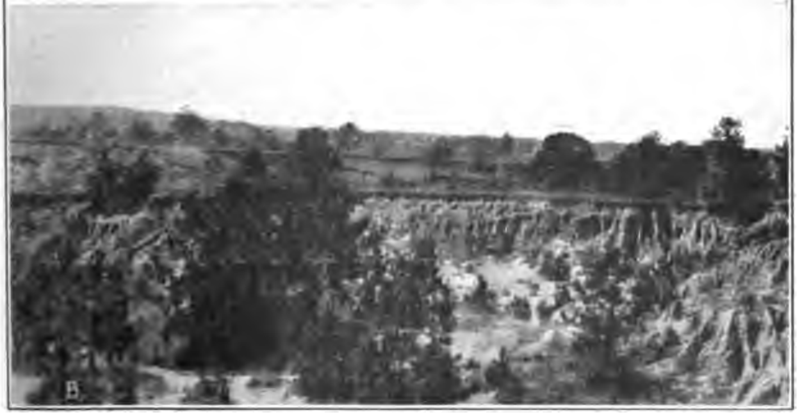
A.—Land in northeastern Kansas formerly cultivated but now used for pasture because of gullying and sheet erosion. The gullies are constantly cutting deeper and fingering out over a wide area
B.—Sheet erosion on almost flat rich black Iowa soil where the first evidence of erosion is the exposure of patches of the clay subsoil
C.—Area in western Texas representative of the destructive effects of erosion on the dry lands of the West



A.—Destructive erosion started in a cattle bedding ground in the arid Southwest. Even the grass roots can not hold the doomed land

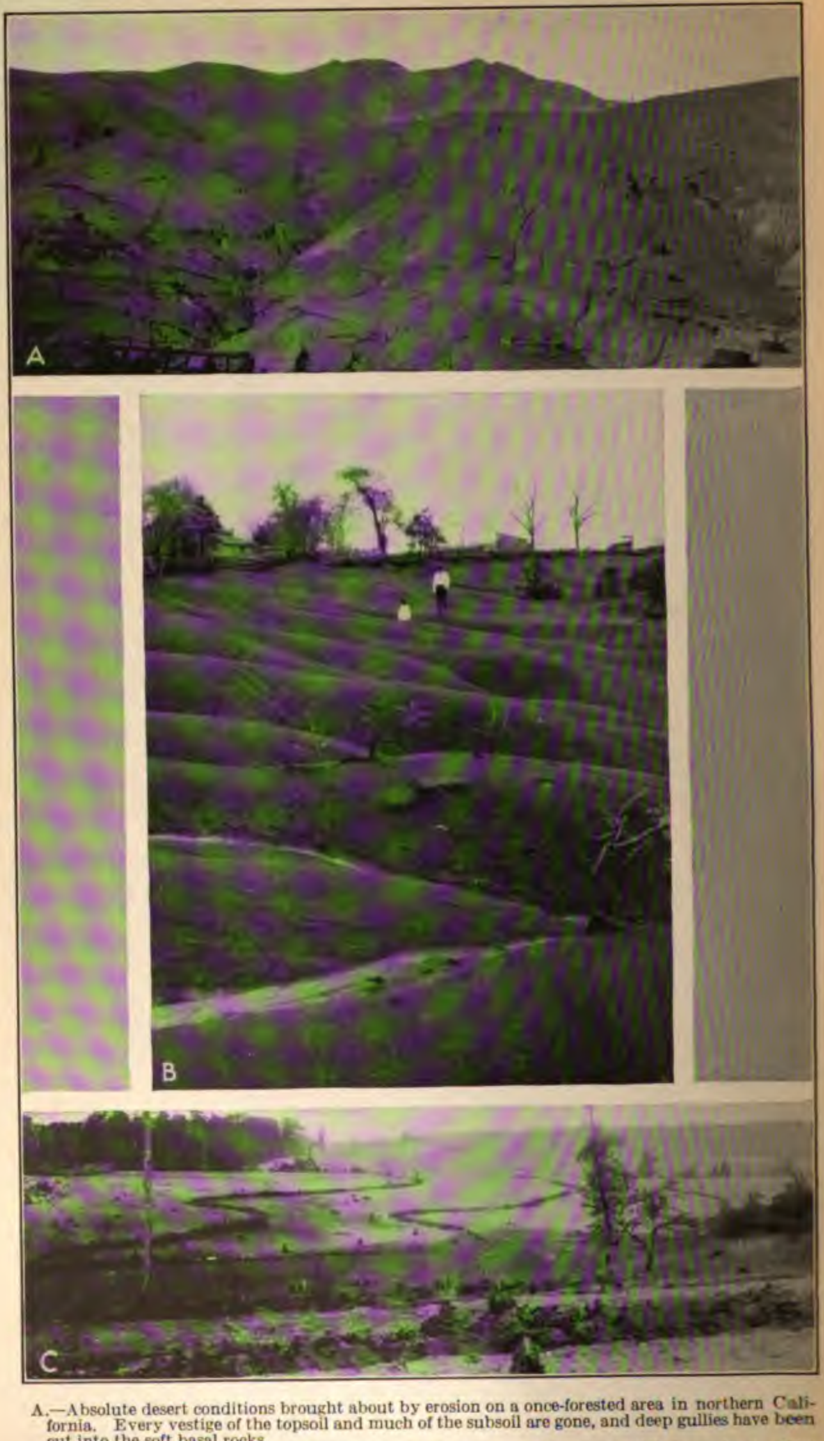
B.—Gully 12 feet 8 inches deep in the dry trans-Pecos part of Texas. It started in a wheel rut and will result in the destruction of the entire valley of rich soil





A.—In Orangeburg fine sandy loam the underlying loose sandy material, if exposed, washes away from under the productive easily tilled soil, which then falls into the gullies during rains, together with great chunks of subsoil

B.—The Grenada phase of erosion in the "Brown Loam" belt. The gullying and scooping-out process extends almost equally in all directions and lays waste this valuable loessial soil



A.—Absolute desert conditions brought about by erosion on a once-forested area in northern California. Every vestige of the topsoil and much of the subsoil are gone, and deep gullies have been cut into the soft basal rocks
B.—Intermediate stage of land destruction on Susquehanna soil having a stiff clay subsoil. The devastation has almost reached the stage at which any attempt at reclamation will be unprofitable
C.—Properly terraced field in the piedmont region. Unprotected soil of this type depreciates rapidly because of both sheet erosion and gullying

with their supply of lime and fresh organic matter, some temporary increase of productivity necessarily will follow the recession of the water. The degree of this increase can not be estimated with much accuracy with the small amount of available data; but probably its tangible money value does not greatly exceed 75 cents or a dollar to the acre of cultivated land each year for several years following a flood. It must be remembered that the Mississippi delta lands, particularly the predominant "buckshot" soil (Sharkey clay), as well as many of the other alluvial soils of the country, are among the richest soils in the world.

THE DANGER OF AVERAGES

The effect of erosion is extremely variable from place to place, on varying soil and varying slope, with varying vegetative cover and method of land usage. Hence, the average depth of surface denudation that has been commonly computed from river discharges alone, means very little. It implies that the surface everywhere, on steep hillsides and flat prairies, on sand dunes, loam and clay, is being planed down at an equal rate. This is far from the truth. The estimate so often read that erosion is lowering the Mississippi Basin at the insignificant rate of 0.0028 inch annually, is not only too small as an average, but since erosion does not operate over large areas of varying soils according to any plan of averages, such a statement is dangerous both for its inaccuracy and complacency.

A most important thing to know about soil erosion is the rate of cutting away the topsoil, and after that the subsoil of the individual soil types, in those regions of the more vulnerable lands, such as the region of loessial soils, the region of the Susquehanna soils, the Knox, Marshall and related soil regions, the Cincinnati soil region, the Houston clay soil region, and the regions where Orangeburg, Decatur, Cecil, Dekalb, Reeves, Vernon, Putnam, Fairmount and numerous other soils are important.

The studies already made in connection with soil-survey work show that there are many types of erosion, due to many variants, that have to do with the process, chief of which are, (1) soil type, (2) degree of slope, (3) climate, (4) vegetative cover, and (5) method of usage. Some soils can be cropped with a fair degree of safety on slopes having a gradient up to about 20 per cent, such as some of the very porous gravelly soils of the chert ridges in the southern part of the Appalachian Valley. On the other hand, some soils can not be cultivated without steady decline due to erosion, even where the slope does not exceed 1 or 2 per cent. The Knox silt loam, for example, is such a soil. On this soil erosion goes on in all tilled fields where there is any slope whatever.

On some soils greatest erosinal damage is done by gullying; on most soils, however, greater wastage results from that slow type of erosion called sheet erosion. On the Cecil soils of the piedmont region deep, broad V-shaped gullies form and finger out rapidly, whereas on the Orangeburg soils, the sides of the ravines are more nearly perpendicular, and they extend by a process of caving, when the loose sand of the substratum is washed out, so that rapid widening and head-on extension takes place. (Pl. 7, A.) On the Grenada soils of the "brown loam" belt, by reason of a compact subsoil layer peculiar to this group of soils, the washing extends more nearly equally in all directions, and rapidly invades broad areas of fine loessial land wherever the erosion has been neglected in its infancy. (Pl. 7, B.) On gravelly red land in northern California, where smelter fumes have annihilated the forests and destroyed almost every vestige of vegetation, extremely deep, narrow ravines have developed, which make travel over these areas difficult and even dangerous. (Pl. 8, A.) On soils like the Susquehanna, in which impervious heavy clay lies near the surface, the material of the cultivated soil is converted quickly into an approximate liquid condition during rains. This causes the surface substance to flow away rapidly. Following this skinning-off process, the exposed stiff clay is attacked by erosion and gradually cut to pieces by gullies that render the land absolutely unfit for further cultivation. (Pl. 8, B.) Numerous other variations of the manner by which soils erode could be given, but this will not be necessary for the purposes of this circular.

Although there is some erosion on most tilled and bare areas, and probably always will be, wherever water runs downhill, provided the soil is not frozen or protected by hard snow, the damage is greatest in the southern and central parts of the Temperate Zone and in the Tropics. So long as the ground is congealed freezing gives practically complete protection, save on those soils that "heave" badly. Slowly falling rains are everywhere much less destructive as an erosional agent than hard, beating rains. For example, no important effect of surface wash is observable on cultivated slopes of the Fairbanks silt loam, a wind-laid soil, in the Tanana Valley in northern Alaska, where the ground is frozen during eight or nine months and the light precipitation occurs almost entirely as drizzling rain and light showers.

By simple and well-known laws of mechanics the erosive power of flowing water increases enormously with increase of slope, but the destruction accomplished varies greatly with the soil type. Deep sandy soils, as a rule, do not wash severely, especially where the subsoil does not consist of impermeable clay or hardpan. However, some areas of sandy land, such as the Norfolk sand, do wash rather badly, and even gully on those slopes where there is impervious clay at a depth of 4 or 5 feet or less, as is true of areas in east Texas having a stiff subsoil like that of the Susquehanna clay.

RELATION TO FLOOD CONTROL

It is obvious that the erosional débris entering the streams adds to the volume of the water. It is equally obvious that those methods of soil conservation which have been found effective in slowing down or controlling soil erosion, chiefly terracing the land and the growing of trees, grass, and other soil-holding plants, are also methods which will cause more water to be retained in the surface soil and to be stored in the subsoil. Terracing of fields and the growing of trees, grasses, and shrubs on idle lands and areas too steep for cultivation, and upon soils that are highly susceptible to washing, as a combination of practices, will, it is believed, have considerable to do with flood reduction by decreasing the runoff and washoff from many land areas. Soil conservation is somewhat synonymous with moisture conservation. Nothing will hold back all the water, of course, but enormous quantities can be held temporarily or stored for summer-crop use, especially in the subhumid regions. At the same time the rich topsoil can be conserved by these proved implements of soil and water conservation. Soil conservation, therefore, should be an important adjunct of any long-continued system of flood control. To those who have seen the water from heavy rains rushing down unprotected cultivated slopes and bare areas, surcharged with soil matter, and carrying even gravel, cobbles, and bowlders, it is not necessary to argue about the effective contribution widespread use of these soil-conserving methods would make toward flood control as supplementary measures to protection with levees, spillways, and reservoirs.

Suspended material to the amount of 428,715,000 tons annually passes out of the mouth of the Mississippi River alone. This is but a part of the solid material that enters the river and its tributaries since much is left stranded somewhere along the pathway to the sea. In considering the relation of this water-transported erosional material to increased floods, it is necessary to take into account its full significance, along with that of a far greater amount stranded between the source of supply and the streams, in its relation to the increased amount of water flowing off the land areas which have contributed the material. So many tons of silt in the river stand, unmistakably, for so many denuded or partly denuded acres of sloping land somewhere upstream—land enabled by its denuded condition to contribute to the stream at a faster rate more of the rain that falls upon it.

In discussing the relation of forest and other forms of vegetative cover to run-off water and floods, it is frequently contended that, although the methods may have value, the time required for a forest to grow up is too great for this means of assistance to have any important relation to flood problems requiring immediate attention. In this connection the fact should not be lost sight of that the roots of trees and of other plants begin to function as effective agents for holding soil against erosion very shortly after the seedling begins to grow. Greatest efficiency in this respect will come, of course, when the forest or other vegetative cover, as grass, bushes, and chaparal, has made sufficient growth to develop an absorptive, spongy cover of vegetable litter. The immediate effectiveness of grass in holding both soil and water has been conclusively shown by results of the erosional test referred to above. It is said by those familiar with early conditions in the Prairie States that before the extensive cultivation of the land the matted turf of the prairies, in many places, hung like canopies over the banks of streams that carried clear water throughout the year. With the breaking of the land this situation was changed. The streams are more frequently dry in summer and are more heavily laden with silt when the rains come.

The following relates to the effects of rains on sloping areas in Orange County, Calif., following removal of a bush growth by fire:[7]

> During the Orange County Farm Bureau Forestry Tour on November 19th, a remarkable demonstration of the effectiveness of chaparral cover in conserving water by preventing destructive erosion was seen at the Harding reservoir.

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[7] Information furnished by C. F. Shaw, University of California, in a letter to the writer. Data obtained from Extension Service Report, December, 1927.

In October, 1926, the heavy chaparral cover on this watershed was almost entirely destroyed by fire, leaving the slopes unprotected. During November a heavy rain fell during a 24 hour period. Santiago Creek quickly became a turbulent mass of muddy water, containing over 60% solid matter washed from the burn. The Santa Ana River, which in the past had never had a peak flow of more than 8,000 second-feet during similar rains, showed approximately four times that at the height of the flood.

Harding reservoir was completely filled with rocks, silt and ashes from the burn, and a deposit of a half inch to an inch of this material was left over the entire bed of the Santa Ana River when the flood subsided. Other streams in the vicinity, where watersheds were untouched by the fire, showed scarcely any rise at all, and the water in all of them was clear throughout the storm. After many weeks of shoveling and washing, the capacity of Harding reservoir is less than one-fourth of its original volume.

LIMITED AMOUNT OF DATA AVAILABLE

In this country only a limited amount of information has been acquired concerning the rates of erosion on different soil types, the holding effect of terraces of different build or the possibility of reenforcing them with various stabilizers such, perhaps, as grass, shrubs, or vines, and the rate of alluvial deposition under varying conditions. Only three or four soil types of the many involved have had their susceptibility to erosion measured. It will be observed in reading this circular that little information other than estimates and observations have been given. This is because exceedingly little research work has been done on the subject. It is not known, for example, precisely what type of terrace or what degree of terrace slope is most applicable to the loessial soils of the Marshall, Memphis, and Knox series. It is known that some types of terrace have not given entirely satisfactory results on these peculiar friable soils of such exceedingly high silt content and such low content of clay to bind the silt. Possibly the Mangum terrace, if properly modified and given precisely the right slope, would effectively control erosion on these exceedingly vulnerable soils. Information greatly needed in connection with the problem of erosion should be made available through experimentation and research work as speedily as possible. If a particular type of terrace does not hold in one place and does hold elsewhere, the reason for the failure, as well as for its success, should be determined and the significance of the facts turned over to the farmers of the Nation in forms available for practical use.

As a Nation we are doing very little to abate the evil effects of erosion. Every one who knows anything about it admits the problem is a serious one, but few realize how very devastating is the wholesale operation of erosion. There is necessity for a tremendous national awakening to the need for action in bettering our agricultural practices in this connection, and the need is immediate. Terracing of sloping areas to prevent erosion has been carried on for a long time in the southeastern part of the United States. (Pl. 8, C.) Recently use of this method has extended across the Mississippi River and is being extensively and increasingly employed in Texas, Oklahoma, and Arkansas. The Federal land bank at Houston recently adopted the policy of requiring all vulnerable fields to be terraced before money is loaned on the land. The bank has employed an erosion expert, who, according to press dispatches, not only decides whether or not the property upon which a loan is asked needs terracing, but also goes out and instructs the farmer how to build a terrace if he is unacquainted with the engineering side of this method of conserving soil.

In the region north of Oklahoma and Tennessee the farmers, as a rule, do not know what a terrace is. Most of them have never seen one, and many of them have never heard of this valuable method of soil conservation. In other instances they are not used because the farmers have not been convinced that they are needed, having heard so much about plant food stolen by crops and so little about soil stolen bodily by erosion. Again, terraces are not used because the farmers have not known how to construct them.

Terracing is a very practical method of saving the land against rainwash. (Pl. 9, A and B.) In general the construction of these field embankments is not very costly, and when they are properly built they will pay the cost of construction and maintenance many times over. Although all the details relating to the best methods for terracing some of the peculiarly vulnerable soils are not fully known as yet, it is known that the broad-base, variable-graded ridge terrace, known as the Mangum terrace, properly laid out and built, is a highly efficient instrument for protecting vast areas of land now wasting through the effects of sheet erosion operating increasingly on unprotected slopes. Exceedingly steep slopes, of course, can not be saved by any method of terracing (pl. 9, C), save those expensive methods of building rock walls and huge retaining embankments, such as have been made abundant use of in parts of the Mediterranean Basin and other regions of the world where there is no excess of available farm land and where labor is abundant and cheap. In this country these steeper slopes should be used in accordance with their best adaptation from the economic viewpoint of America, i. e., for forestry and grazing. Probably in this country those erosive sloping lands which range in texture from silt loam to clay and, which have bedrock at a depth of a foot or less beneath the surface, should not be cultivated under any circumstances for generations to come, if ever. There are other soil conditions, also, where the land can not be economically saved by terracing, some even where the mere clearing off of the timber may be followed by wasteful washing. (Pl. 10.) All the details can not be given here.

In addition to terraces soil-saving dams, brush fillings and other obstacles to continuous washing have been successfully employed locally in combating erosion.

There are national associations for the preservation of wild flowers and for the preservation and propagation of wild life but none for the preservation of the soil. Conservation of this most fundamental and important of all resources is seldom seriously considered by any one not directly or indirectly associated with the ownership or management of a farm, and it is too infrequently considered even by the farmers themselves. Erosion is a very big problem. It is doubtful if the farmer can handle it alone.

SOIL-TYPE INFORMATION

The kind of information that is most needed about erosion is that which will apply to definite kinds of land—to soil types that vary from place to place, not only in their crop adaptations and requisite methods of cultivation, but in their resistance to erosion and in the means necessary for checking erosion. Any other method of procedure in studying the problem will be, in no small degree, wasted effort, as methods that may apply to one soil may injure a soil of different character.

As has already been pointed out, terraces must be adjusted carefully, not only to soil type but to slope. If the protection embankment is given too much or too little slope, there is danger of breaks and intensified washing that may exceed that prevailing before the terrace was constructed. In one instance terraces built on Granville sandy loam, in the southern piedmont region, broke with the first heavy rainfall, causing almost complete destruction of the area involved; whereas terraces of the same type made on the Wadesboro clay loam at about the same time and with the same slope withstood the rains that destroyed those on the other soil.

In this connection it is pertinent to refer to a statement of G. E. Martin, of Oklahoma (*14*):

> A half finished job of terracing is likely to result in wasted time, wasted effort, and wasted soil, and tends to bring into disrepute the most satisfactory means, so far determined, of preventing the enormous annual loss of soil fertility which now occurs. This loss constitutes a most serious drain upon the agricultural industry. It is very unlikely that any other industry could suffer such severe losses and survive.
>
> The importance of measuring the slope to determine the proper spacing of terraces can hardly be over emphasized. Too heavy a grade or too much fall along the terrace line, can defeat the moisture conservation objective and may result in hillside ditches instead of terraces.

As an illustration of the important rôle soil character plays in determining the rate of soil erosion, comparisons might be made between the results obtained at the erosion station in subhumid west Texas and those obtained in the humid piedmont of North Carolina. On a 2 per cent slope of the Abilene clay loam at Spur, Tex., 41 tons of soil matter were lost by erosion from 1 acre of land with 27 inches of rainfall; whereas at the North Carolina station only 25 tons of soil matter were removed from 1 acre on a 9 per cent slope with 35.6 inches of rainfall. In other words, although the slope in the latter instance was more than four times steeper than that in the former instance, the eroded material was very much less on the steeper slope.

It is not the purpose of this circular to go into the details of methods for preventing soil erosion, but rather to point to the evils of this process of land wastage and to the need for increased practical information and research work relating to the problem. Instructive bulletins have been published by the United States Department of Agriculture and by the States containing details relating to the best-known methods of checking soil erosion and of filling gullies. Bulletin No. 512, Prevention of the Erosion of Farm Lands by Terracing (*18*), published by the United States Department of Agriculture, is especially instructive in connection with the theory and the practical side of terrace construction; and Farmers' Bulletin No. 1386, Terracing Farm Lands (*19*), is another useful bulletin relating to the subject.

THE WARNING OF A GEOLOGIST

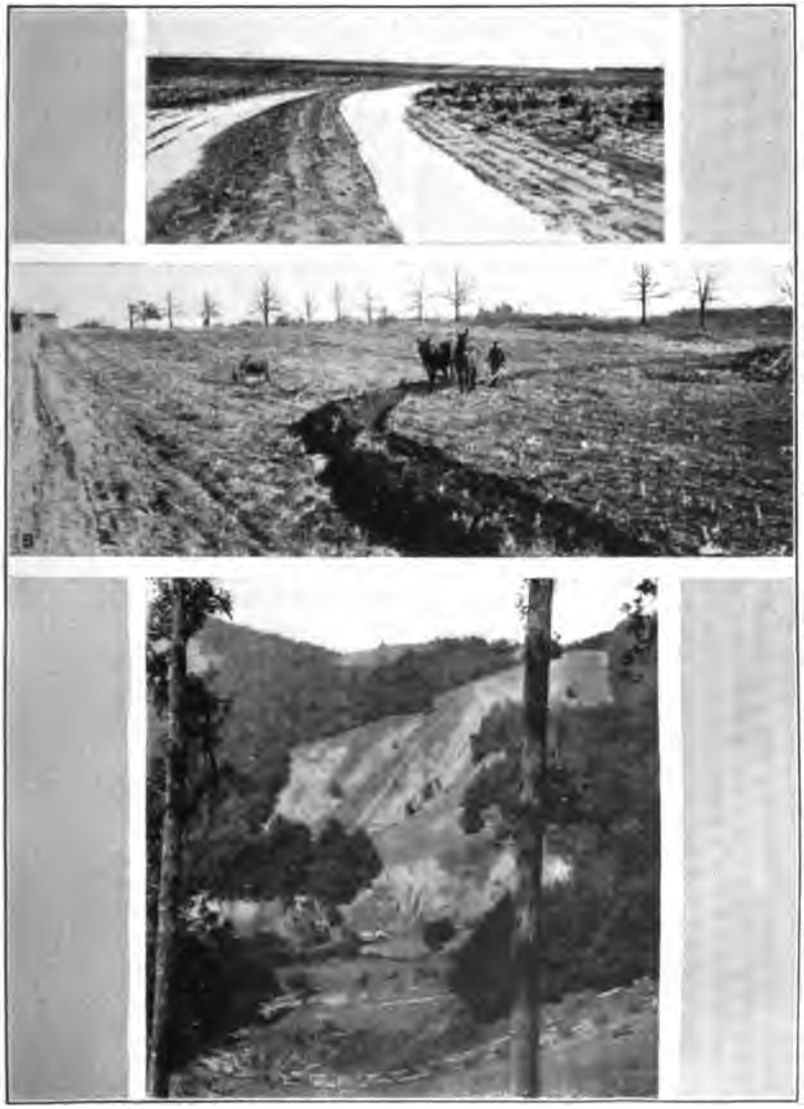
In his address before the Conference of the Governors of the United States, held at the White House in 1908, T. C. Chamberlin, of the University of Chicago, had the following to say in relation to erosion (*5*):

> Let us turn at once to the basal factor in the problem, the rainfall, the soil, and the soil-wastage, the special theme of this hour. The rainfall is an inherited asset, the soil is an inherited asset . . . but reckless soil-wastage is a serious error. Soils are the product of the atmosphere and its waters modifying the rock surface. When the atmospheric waters have aided the air in producing soil by rock decay they may pass, on the one hand, into plants or back to the surface soil, and thence to the atmosphere by evaporation, or, on the other hand, they may pass on down to the ground-waters and thence into the streams. The alternative is to rush away as foul erosive floods on the surface, wasting soil and plant food, gullying the surface, choking the ravines, flooding the valleys, silting the pools, filling the reservoirs, sweeping out the dams, barring the streams and clogging the harbors. If it shall be found that all or nearly all the waters should go into the soil and thence into the underdrainage, coming out slowly and steadily by seepage and by springs into the streams, clear and pure, these streams should present nearly ideal conditions for water-food, for power, and for navigation. The solution of the soil problems may therefore be, in large part, the solution of the whole complex of problems of which navigation is the last term.
>
> While soils are formed by the action of the atmosphere and its waters on and in the underlying rock (aided by plants and animals), their surfaces are carried away by wind and wash. At any instant, then, the depth of the soil measures the lag of removal behind production.
>
> We have as yet no accurate measure of the rate of soil production. We merely know that it is *very slow.* It varies obviously with the kind of rock. Some of our soils are derived from material already reduced to a finely pulverized condition. Such are the lowland accumulations from highland wash. Such also is the glacial drift, rockflour rasped from the face of the ledge by the glacial file, and ground up with old soils. On such a base of half-prepared material, soils may be developed with relative rapidity; but even on these, when the slope is considerable, wind, wash and cropping remove the surface much too fast for stable fertility. . . . Without any pretensions to a close estimate, I should be unwilling to name a mean rate of soil-formation greater than one foot in 10,000 years on the basis of observation since the glacial period. I suspect that if we could positively determine the time taken in the formation of the four feet of soil next to the rock over our average domain, where such depth obtains, it would be found above rather than below 40,000 years. Under such an estimate, to preserve a good working depth, surface wastage should not exceed some such rate as one inch in a thousand years. If one chooses to indulge in a more liberal estimate of the soil-forming rate, it will still appear, under any intelligent estimate, that surface wastage is a serious menace to the retention of our soils under present modes of management. Historical evidence enforces this danger. In the Orient there are large tracts almost absolutely bare of soil, on which stand ruins implying former flourishing populations. Other long-tilled lands bear similar testimony. It must be noted that more than loss of fertility is here menaced. It is the loss of the soil-body itself, a loss almost beyond repair. When our soils are gone, we too must go, unless we shall find some way to feed on raw rock or its equivalent. The immense tonnage of soil-material carried out to sea annually by our rivers, even when allowance is made for . . . material derived from the river channels, is an impressive warning, of the danger of negligent practices. Nor is this all; the wash from one acre is often made the wastecover for another acre, or for several. Sometimes one's loss is another's gain, but all too frequently one's loss is another's disaster; and the 1,000,000,000 or more tons of richest soil-matter annually carried into the sea by our rivers is the Nation's loss.
>
> Some of the soluble substances . . . formed at the base of soils are necessary plant food, while some are harmful; but what is more to the point, all are harmful if too concentrated. There is need therefore that enough water pass through the forming soil, and on down to the ground-water and

> out through the underdrainage, to carry away the excess of these products. An essential part of the best adjustment is thus seen to lie in *a proper apportionment of the amount of water which goes through the soils.* If this be not enough, the plants will suffer from saline excess; if it be too much, the plants may suffer from saline deficiency.
>
> Here, then, lie a series of possible excesses and deficiencies; between them falls the golden mean which gives best results. Thus the problem of soil management is a problem of proper balancings and adjustments, a problem to be solved by science and common-sense forced to their best by the energy and intelligence of the American farmer.
>
> The key to the problem of soil conservation lies in due control of the water which falls on each acre. This water is an asset of great possible value. It should be looked upon as such. It should be computed by every acre-owner as a possible value, saved if turned where it will do good, lost if permitted to run away, doubly lost if it carries also soil values and does destructive work below.
>
> Experimental studies have shown that, on the average within our domain, *crops can use to advantage all the rainfall during the growing season,* and that, *in most cases, crops are the better for all the stored supplies that can be carried over from the non-growing seasons.* This greatly simplifies the general problem, for it justifies the conclusion—to which there are many local exceptions, of course—that the highest crop values will usually be secured when the soil is made to absorb as much of the rainfall and snowfall as practicable. In securing this maximum absorption and internal soil-work, the run-off, and hence the surface wash, will be reduced to a minimum. It has already been seen that the wash of even this inevitable minimum is likely to be still too great to keep the proper slow pace with soil-generation, when the surface has much slope . . . The practical problem then lies almost wholly in retaining and passing into the soil the maximum of the precipitation. Obviously, this gives the minimum of wash to foul the streams, to spread over the bottom lands, to choke the reservoirs, to waste the water-power, and to bar up the navigable rivers. *The solution of the problem for the tiller of the soil essentially solves the whole train of problems running from farm to river and from crop-production to navigation.*

LOOKING FORWARD

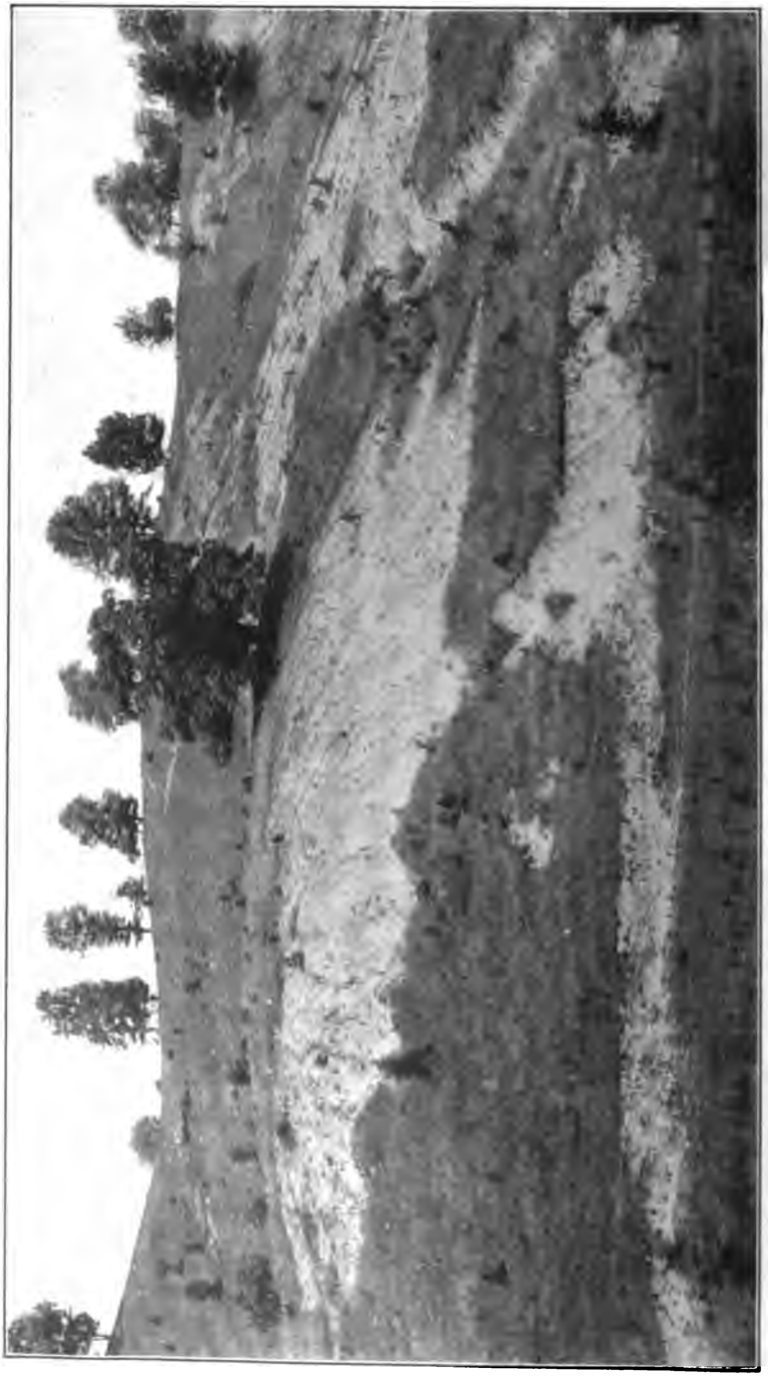
It must be stated that this circular does not undertake to tell the full story of the appalling wastage being caused by soil erosion. It merely refers briefly to some of the working processes of this greatest enemy to the most valuable asset of mankind (the agricultural lands), to some minimum estimates relating to the damage wrought, and to the meagerness of fundamental data concerning the problem. To visualize the full enormity of land impairment and devastation brought about by this ruthless agent is beyond the possibility of the mind. An era of land wreckage destined to weigh heavily upon the welfare of the next generation is at hand. Indeed, what has happened already and what is going on at an ever-increasing rate of progress is pressing upon many thousands of farmers now struggling to win subsistence from erosion-enfeebled soil. That the evil process is gaining momentum is due to the wearing away of the topsoil, which was more productive and more resistant to rainwash than the subsoil that is taking its place. That some 15,000,000 acres or more of formerly tilled land has been utterly destroyed by erosion in this country is but an insignificant part of the story, for it is the less violent form of erosional wastage, sheet erosion, that is doing the bulk of the damage to the land. Land depreciation by this slow process of planing off the surface is of almost incalculable extent and seriousness, and since the denudation does not cease when the subsoil is reached, there must be in the near future, unless methods of land usage are very radically changed, an enormous increase in the abandonment of farm lands.



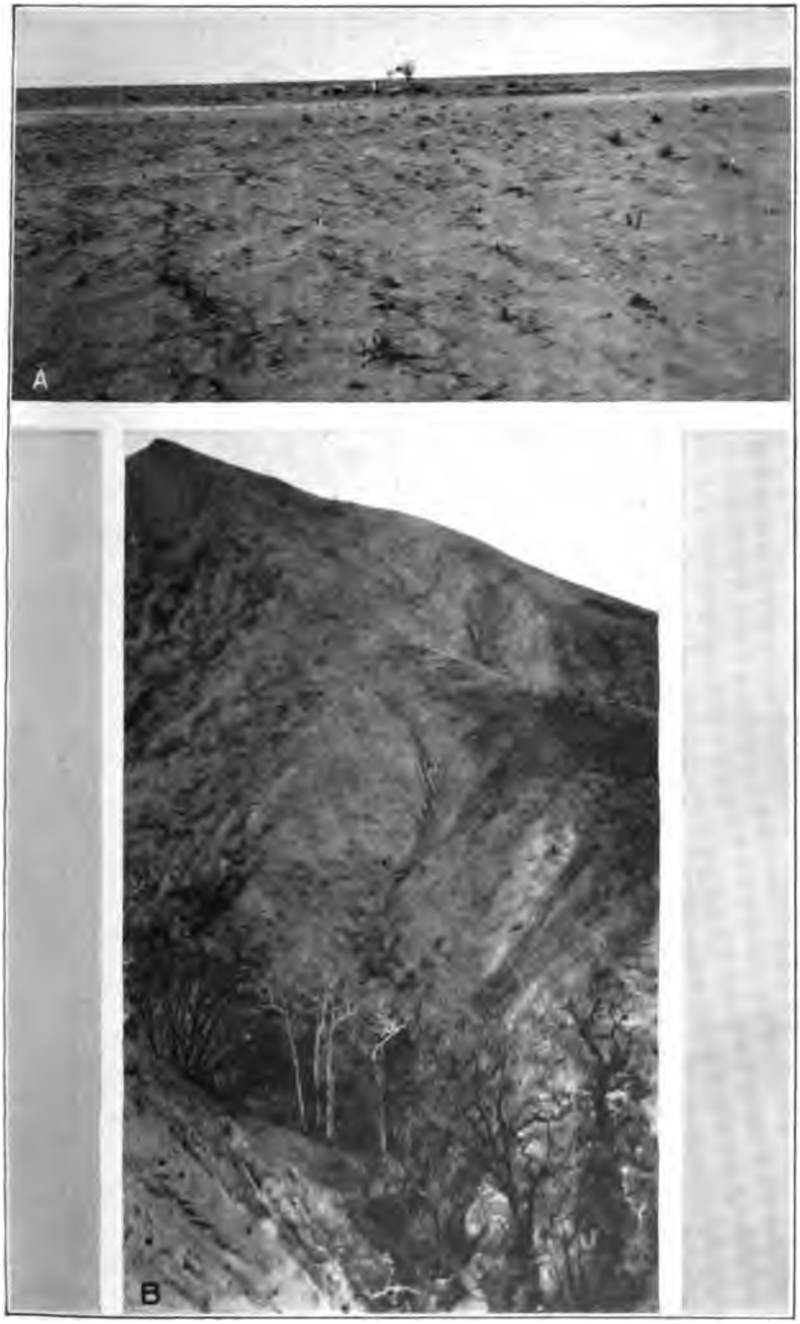
A.—Properly constructed terrace in the Black Waxy belt of Texas. The sheet of water is flowing slowly and harmlessly off the field

B.—After its proper location has been determined, an efficient terrace can be plowed up without much difficulty

C.—Mountain land of the Blue Ridge destroyed after a few crops of corn. Such land should not be cleared

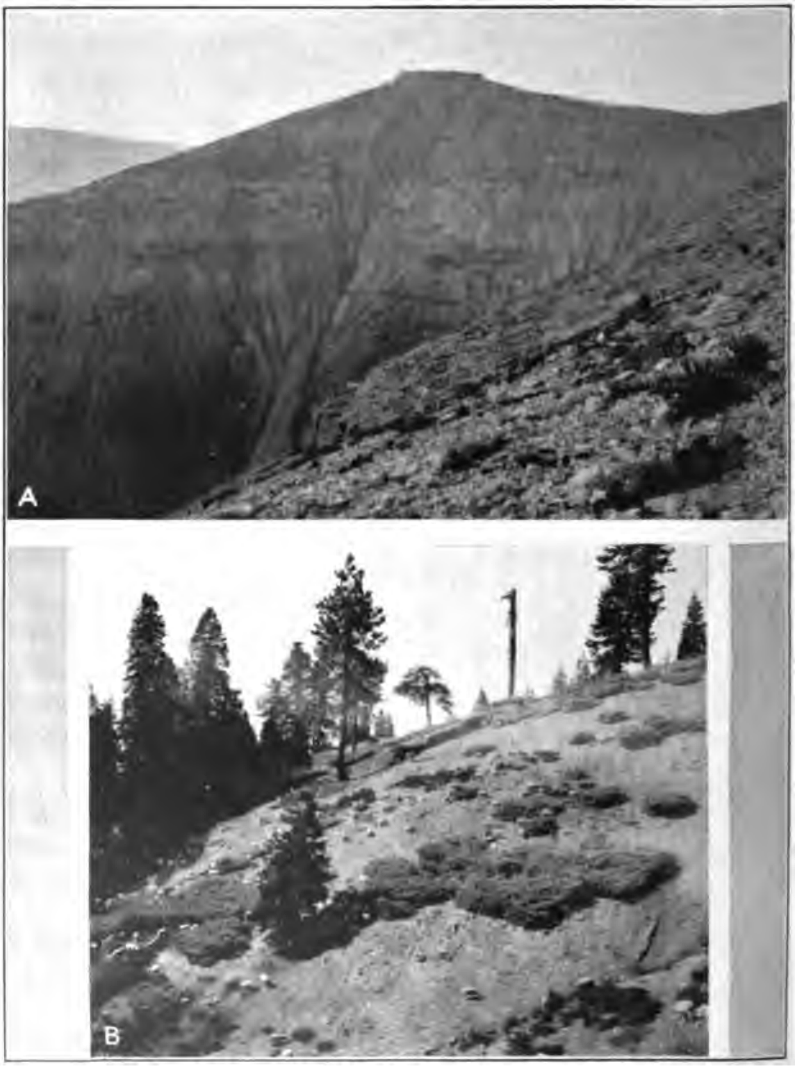


Destructive erosion on an unwisely cleared slope in the Blue Ridge part of the southern Appalachians



A.—Wind erosion, the result of drought and trampling, New Mexico. Excessive concentration of cattle near permanent water during drought periods results in serious trampling. Wind has removed 5 or 6 inches of soil, exposing the roots of the few remaining plants to desiccation

B.—Fire has destroyed the vegetation, and the steep slopes are rapidly washing away (California)



A.—A barren waste. Smelter fumes have destroyed the vegetation (Arizona)
B.—All the herbaceous vegetation has been destroyed by overgrazing. The brush and timber are insufficient to prevent serious sheet and shoe-string erosion and excessive soil deterioration

What would be the feeling of this Nation should a foreign nation suddenly enter the United States and destroy 90,000 acres of land, as erosion has been allowed to do in a single county? Any American of live imagination knows that the people of the United States would willingly spend $20,000,000,000 or as many billions as might be necessary, to redress the wrong. Because rain water was the evildoer in this instance, which is but one of many, is the act forgiveable and is there no occasion for concern about it?

It is not necessary to go to China or to some other part of the world for examples of what eventually happens to unprotected slopes of cultivated areas. There is an abundance at home, not yet so vast in area as in China, but just as bad, and by no means small. It is well to observe, however, that millions of human beings have been driven out of the wasted uplands of China into the valleys of the great rivers, where the population is so dense and the land so completely used that even the roots of grain crops are dug for fuel. China cut the forests from the uplands and made no provision for protecting the bared slopes. Erosional débris sweeping out of these wasting highlands has rapidly extended the river deltas and made floods ever more difficult to control. After 4,000 years of building dikes and digging great systems of canals, the Yellow River broke over its banks and brought death to a million human beings during a single great flood. During one flood that great river, known in China as the "scourge of the sons of Han," changed its channel to enter the sea 400 miles from its former mouth.

No one, of course, wants anything remotely like this to take place in this country, but "coming events cast their shadows before." That the greatest flood of which we have reliable records came down the Mississippi in 1927 was a prophetic event. G. E. Martin's statement (*14*) about erosion as an enemy to agriculture—"It is very unlikely that any other industry could suffer such severe losses and survive"—is prophetic. That bare land at the Missouri Agricultural Experiment Station was found to be wasting 137 times faster than land covered with bluegrass, on a slope of less than 4 per cent gradient, is prophetic. That many millions of acres of cut-over land lie bare and desolate and exposed to the ravages of fire and erosion, with but pitifully little done toward reforestation, is prophetic. That minimum estimates show that the rate of plant-food wastage by erosion is twenty-one times faster than the rate at which it is being lost in crops removed, is prophetic.

These shadows are portentous of evil conditions that will be acutely felt by posterity. Shall we not proceed immediately to help the present generation of farmers and to conserve the heritage of posterity?

The writer, after 24 years spent in studying the soils of the United States, is of the opinion that soil erosion is the biggest problem confronting the farmers of the Nation over a tremendous part of its agricultural lands. It seems scarcely necessary to state the perfectly obvious fact that a very large part of this impoverishment and wastage has taken place since the clearing of the forests, the breaking of the prairie sod, and the overgrazing of pasture lands. A little is being done here and there to check the loss—an infinitesimal part of what should be done.

PART 2. SOIL EROSION ON WESTERN GRAZING LANDS

By W. R. CHAPLINE

INTRODUCTION

The toll the West has paid to soil erosion is enormous. Countless slopes, once covered with rich soil and a dense carpet of herbaceous and browse plants capable of profitably supporting millions of cattle and sheep, have been so wasted by sheet and gully erosion following depletion of the vegetation that they can now support far less than half the number of livestock that once grazed upon them. Furthermore, the loss of the valuable surface soil and the exposure of the less productive subsoil have made difficult the reestablishment of an abundant stand of plants. Fertile valleys, their good soil cut away by silt-laden flood waters or covered with sand and gravel, have had their value seriously impaired or have even had to be abandoned. The silt has finally been carried to the mouths of rivers to clog channels and hamper navigation.

Water available for agriculture, power, and industry will largely determine the development and prosperity of the West. In 1920 approximately 19,000,000 acres in the West were under irrigation, and it was estimated that this area could be extended to 51,000,000 acres by the conservation and development of the entire water supply (*10*). Erosion, however, is already endangering established projects and making prospective ones uncertain. A more adequate protective covering is necessary to safeguard these watershed interests.

Erosion, the removal of the soil cover by water or wind, is taking place everywhere, but under favorable conditions nature starts at once rebuilding the soil from the decomposition of rocks or by the addition of humic material from decaying vegetable matter. Numerous factors, of which climate, soil, topography, and geologic formation are doubtless the most important, influence these processes, but the vegetative cover is the main single controllable factor. It is recognized that forest cover furnishes the greatest protective value for preventing erosion and soil washing and for regulating stream flow. It is, therefore, important that forest growth, including its understory of herbaceous and shrubby vegetation, be maintained wherever possible at the headwaters on all streams used for irrigation, power, or navigation. West of the one hundredth meridian, however, forests grow on only 13 per cent of the land area. It falls to herbaceous and shrubby vegetation to afford the necessary protection to the soil and stream flow on the remaining 87 per cent.

It is this vast area of unforested land that largely supports the range livestock industry which in turn plays a principal part in the prosperity of the West. On these western ranges the protective cover of vegetation varies from a very sparse stand of browse and annuals on desert areas to an almost complete cover of grass on untimbered alpine slopes where soil and moisture are favorable. The normal stand of native vegetation for the region as a whole is considered to be a stand covering 50 to 60 per cent of the soil surface.

EROSION AGENCIES ON RANGE LANDS

The natural balance on these arid and semiarid lands, between the forces that tear down and those that build up the soil, is a delicate one, but if the vegetative cover is not disturbed erosion is usually slight. Natural agencies may occasionally produce abnormal erosion. Man's activities, however, by reducing the vegetative cover or altering the topography or soil, can and do upset the balance completely. Where this occurs these activities are seldom abated, and severe erosion follows. Once started, this may develop to disastrous proportions.

NATURAL AGENCIES

Drought, the shortage of rainfall for a year or more, usually accompanied by excessive evaporation, may cause serious depletion of the vegetative stand. If so, it will probably be followed by wind or water erosion or both. (Pl. 11, A.) This is particularly true in the areas subject to a low average annual rainfall. On the Jornada Range Reserve in southern New Mexico, for example, drought caused a reduction of 40 per cent in the density of herbaceous vegetation on ungrazed areas between 1916 and 1919 (*11*) and a still greater reduction in 1922. A similar reduction of herbaceous vegetation was noted by Director Culley on the Santa Rita Range Reserve in southern Arizona, the loss being greater on ungrazed than on properly grazed range.

Cloud-bursts, snowslides, and excessive moisture on slopes, followed by landslides or landslips, may also unbalance the delicate equilibrium which nature has so carefully developed and may lead to excessive erosion. But nature, if unimpeded by man, quickly sets to work to reestablish the balance; the vegetation gradually spreads over the scars, the slopes assume an angle of repose, and eventually the normal conditions return.

FIRES

Of all the man-caused erosion, that resulting from fire has probably been the worst. Everywhere one goes throughout the West, old settlers tell of extensive fires allowed to burn over ranges and forests in the early days, little or no effort being made to stop them. Many of these fires were set for the purpose of exposing minerals or in the mistaken belief that they would improve the range. Even when great effort is made to control them, fires destroy the vegetation on hundreds of thousands of acres in the West every year. A single prairie fire observed in the sand hills of western Nebraska in the spring of 1910 burned the grass from an area 100 miles long and up to 30 miles in width. With recurring fires, the stand of vegetation becomes more open, the length of time the ground is bare increases, and erosion becomes more active.

In California, fires have completely or partially devastated more than 981,000 acres of forest, brush, and grass land. Of brush and grass land alone, they have burned over annually from 1916 to 1921 an average area of 336,000 acres. (*15*) In the southern California brushfields, one may see a 1,000-acre burn wherein practically all of the vegetation, which required years to grow, was destroyed in a few hours. When one stands in several inches of ashes on an extremely steep slope in the center of such a burn, knowing that the humus, "the life of the soil," has been consumed and that those ashes and the surface layer of soil will be washed down the slope with the first dashing rain, he realizes how great is the soil destruction from fire and erosion. (Pl. 11, B.)

MINING

Hydraulic mining along streams throughout the West tore out the valleys and sides of gulches, leaving the débris in the creek beds for high water to carry down to fill the lower river channels or to spread like a wasting hand over fertile farm land. This destruction has been especially severe in California but is now under regulation (*15*).

Smelters, an adjunct to mining, depleted several hundred thousand acres of western range land and completely destroyed the vegetation on a considerable part of it. (Pl. 12, A.) Bennett has already in this circular noted the excessive erosion on the denuded slopes. Damage is still being done, even though in some places recent abatement measures have reduced smelter-smoke injury materially.

OVERGRAZING

Following 1870 there was a rapid expansion of the range livestock industry in the West, especially in sheep raising. By the late seventies the expansion in cattle was in full swing and pressed on with prospects for a rich harvest (*1, 22, 23*). As numbers of livestock increased the palatable forage plants were grazed closer and closer, and their vigor was sapped. Instead of thick grass knee high, of which the early stockmen speak, there were shorter and sparser grass blades and stems; finally many of the plants gave up the struggle, and the stand was thinned. The less valuable plants were then grazed more severely, until they too were practically eliminated. The hungry animals in their search for feed trampled the range, destroying plant roots and packing the soil. The ranges became dust beds. Residents of Utah tell of being able to count the herds of sheep on the mountains by the dust clouds rising as the sheep trailed through the country. Under such conditions there was nothing to check the rain as it fell; the more compact soil could not absorb the water, which ran off and was quickly converted to a slimy mass of flowing mud. Shoe-string gullies started and speedily gained depth, while the main drainage channels became raging torrents. The rich friable surface soil was washed away and the heavy clay subsoil exposed.

Even before 1890 there were more livestock on the ranges than they could support satisfactorily. Oversupply brought a drop in values and caused a greater proportion of animals to be held on the range, until the drought of the early nineties, coupled with the greatly reduced feed supply, wiped out large numbers by starvation and forced stockmen to sell countless others at a loss.

Thus the stockmen have been, in part, victims of circumstance. Under "free," unregulated, and competitive grazing the range of any stockman who endeavored to have plenty of feed on his range would be eaten out by tramp stockmen who were eager to find such "pickings." Then, too, with drought reducing the feed supply 40 per cent or more in a year, it was impossible without control to make the adjustments necessary to assure reserve feed. When prices were high everyone desired to hold stock in the hope of profiting by the rise, and when prices broke there was at times no market whatever for the surplus animals. All of these factors tending to overstocking and overgrazing developed conditions unusually favorable for soil destruction, and there were few ranges of the West which did not suffer severely from erosion in the nineties, a considerable part of which is not yet checked.

The regulation of grazing within the national forests and the consolidation of private holdings have greatly reduced the area of range overgrazed, but extensive areas throughout the West are still deteriorating through excessive or otherwise improper grazing use. (Pl. 12, B.) The most serious situation at present is that on the 196,000,000 acres of unappropriated and unreserved Federal lands with their unfenced, intermingled State and private lands, on which grazing can not now be legally controlled. Much of this public domain lies in the foothills and should furnish the abundant spring and fall feed essential to profitable livestock production. Drought and overgrazing, however, are seriously impairing the feed and watershed values of large expanses of these important Federal lands by robbing them, through erosion, of the soil material necessary to maintain a protective covering.

OTHER AGENCIES

Other agencies, such as the building of roads and trails, the cultivation of steep slopes, the clearing of timber and brush from mountain-valley bottoms, the draining of wet meadows to facilitate cultivation, and the straightening or changing of stream channels, have come about with settlement and have caused erosion of range lands. These, with the exception of attempted hillside farming, have not as a rule caused sheet or shoe-string erosion of the slopes, but by cutting out the rich valley bottoms they have caused considerable damage. Rodents, mentioned earlier by Bennett, by denuding some range areas have thereby caused erosion.

The early roads and trails followed the watercourses through the foothills and mountains. The sod was broken on the slopes, so that water might accumulate and start cutting runways. (Pl. 13, A.) The natural beds of streams were altered to allow teams and wagons to pass, and the water was thus aided in its cutting process. Even to-day the construction of mountain roads without proper drainage is a common cause of unnecessary erosion. Bates (*2*) found, in logging the timber from a mountain wastershed in Colorado, that the scar left by the logging road was largely responsible for an increase of 519 per cent over normal in the sediment eroded from the watershed during the fourth year after cutting. Herbaceous and shrubby vegetation quickly reclaimed the rest of the area, however, and protected the slopes from undue erosion.

Long, narrow, fertile valleys occur throughout the mountain region. Farmers and ranchers have pressed farther and farther back into these valleys, cleared them of their timber and brush or turned under the sod, and cut ditches to drain the marshes, unknowingly removing the natural obstructions and reservoirs which slowed up the run-off. In floods these more effective drainage channels increased the carrying power of the water manyfold and the cutting power enormously. A slight lowering of the stream bed in the valley was enough to start the formation of deep, perpendicular-sided gullies or "arroyos," ever widening and deepening. (Pl. 13, B.)

Many of these arroyos are now 10 to 30 feet deep and 100 feet or more in width, while the larger streams have cut deeper and still wider drainage lines. Only an occasional rancher is doing anything to arrest this cutting and usually only enough to afford immediate protection to his farm land or improvements along the arroyo. As no real attempt is made to control the arroyo it continues extending its tentaclelike arms back and up the draws by accelerating the flow of water over the falls at each finger's end; and it saps the life from the valley and its tributaries by lowering the water table and tearing out the rich alluvial soil. Such a lowering of the water table has drained the valley meadows, forcing a replacement of valuable stands of grasses with a sparser stand of drought-resistant plants of lower value. Increasing flood waters rushing through the channels have cut away the adjacent agricultural lands, threatening their permanency and materially reducing their value. Ninety per cent of the farm land in the Blue River watershed of Arizona was destroyed by just such erosion, the damage over this relatively small area totalling $522,000.[1]

THE SERIOUS EFFECTS OF THE EROSION

The more rapid run-off from the depleted, untimbered slopes, the greater quantities of silt carried, the quicker concentration of high water from small drainages into flood crests that eventually assume disastrous proportions in the West, cause this depletion to play an important part in the distress occasioned in the main river valleys. The losses in the western range region are, however, more readily recognized and are in themselves of sufficient magnitude to demand urgent attention.

FLOOD DAMAGE TO MOUNTAIN VALLEYS

Olmstead (*17*) considered the ultimate destruction of the Safford Valley lands of Graham County, Ariz., by the Gila River floods so certain if not attended to, and so closely related to the serious erosion of slopes and valleys occurring in the upper watershed, that he recommended an expenditure by the Federal Government of $5,000,000, which should cover not only bank protection in the valley (pl. 14, A), but check dams and other erosion control and flood-prevention works on the watershed as well, even though the value of the land to be protected was at that time (1916) approximately only $5,000,000. He emphasized the necessity of vigorously combating flood waters where they start and mastering them there by restoring the vegetative cover (pl. 14, B), by regulating grazing, and by putting in small check dams in the channels.

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[1] UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE. WATERSHED HANDBOOK [FOR SOUTHWESTERN DISTRICT]. 28 p., illus. 1923. [Mimeographed.]

Of 32 agricultural valleys in the national forests of Arizona and New Mexico, only 3, or less than 10 per cent, had no erosion in 1923; 4, or 13 per cent, had been ruined by erosion, 31 per cent partly ruined, and of the remainder 28 per cent had noticeable erosion started. It is estimated that about 100,000 acres of agricultural land in these two States have been lost through erosion, nearly one-fourth as much as has been reclaimed by United States reclamation projects in the two States.[2]

In Utah, Reynolds (*20*) reported that previous to 1888 there was no record of serious floods from the Manti National Forest area. It was originally well protected by an abundant ground cover of shrubs and grasses, which delayed the run-off and prevented erosion. Heavy grazing by horses, cattle, and sheep, however, resulted in the almost complete destruction of this cover. Since 1888 floods of great violence and destructiveness have been common, and it is estimated that up to 1910 they caused a loss of approximately $225,000. This writer urges a restoration of the natural cover of shrubs and grasses and points out that the closing of the upper part of Manti Canyon to grazing in 1903 made it less subject to floods.

Hundreds of thousands of dollars are required yearly to repair and reconstruct roads, trails, bridges, and other public and private works destroyed by flood waters in valley lands in practically all parts of the West.

Furthermore much of the water which is so necessary for periodic irrigation and which should come gradually from underground sources is taken off in the flash floods, leaving irrigated farms to suffer from an inadequate water supply during the latter part of the irrigating period.

SILTING OF RESERVOIRS

One of the worst features of floods is the enormous quantity of silt carried from the slopes and rich valley bottoms along with rocks, bowlders, and other débris out on to valley farm lands (pl. 15, A) or into irrigation and other reservoirs. Talbot (*24*) reports an average deposit of 1 foot annually in 30 southwestern reservoirs used for livestock watering, making the average life for the reservoirs less than 15 years. Such a loss demands most urgent consideration of the silt problem. He recommends, in addition to check dams and other channel obstructions, the restoration of depleted vegetative covering on watersheds and the maintenance of as heavy a covering as possible, especially in the channels just above the reservoirs.

J. W. Taylor, manager of the Water Users' Association of the Elephant Butte project of New Mexico, states that 18,000 acre-feet of silt, equal to 0.7 per cent of its capacity, is entering the Elephant Butte Reservoir annually. While this may appear small, the 140 years which it might require to fill the reservoir with silt is but a short period in the life of the project. Within 50 years one-third of the capacity, the equivalent of a year's water requirements, will be occupied by silt, endangering the water supply for irrigation over a period of several dry years such as is common in the region.

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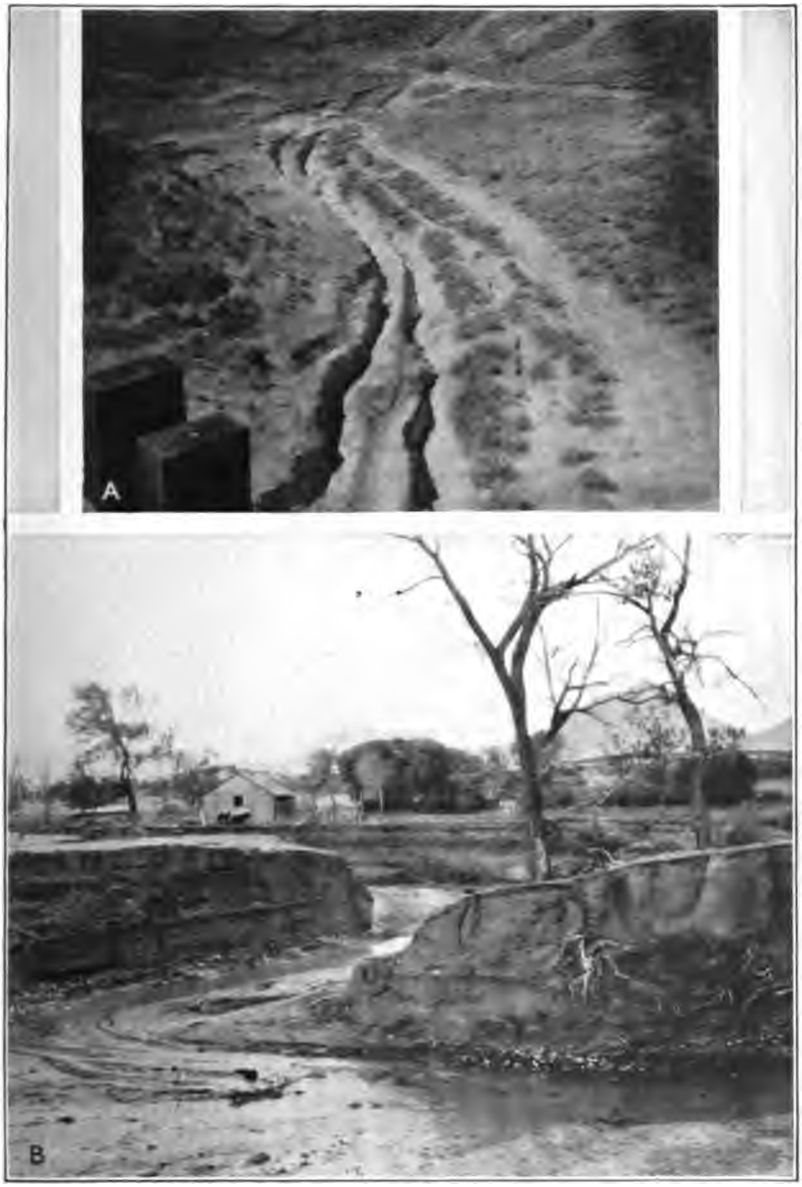
[2] See footnote 1.

For a number of years the rainfall on the watershed of the Roosevelt Reservoir has been below normal. In 1925 the water supply became very low. If the part of the reservoir capacity occupied by silt had been available for water, the shortage would not have been so great. During the dry period rains washed much of the surface soil from slopes into small gullies and occasionally as far as main channels. In 1927 torrential rains fell rapidly and, with the vegetation depleted by drought and overgrazing, caused terrific cutting of slopes. The several years' soil accumulations in the channels were carried farther down the main stream courses, usually to be dropped into the reservoir. Plate 15, B, shows strikingly the enormous quantity of silt, in the upper parts of the reservoir basin, being washed out by erosion of the silt banks and carried down nearer the dam. On experimental plots on the range where the vegetation had made normal growth the roots bound the soil, with the result that soil cutting was not so severe and much water-carried soil coming into the plots from above lodged in grass or brush.

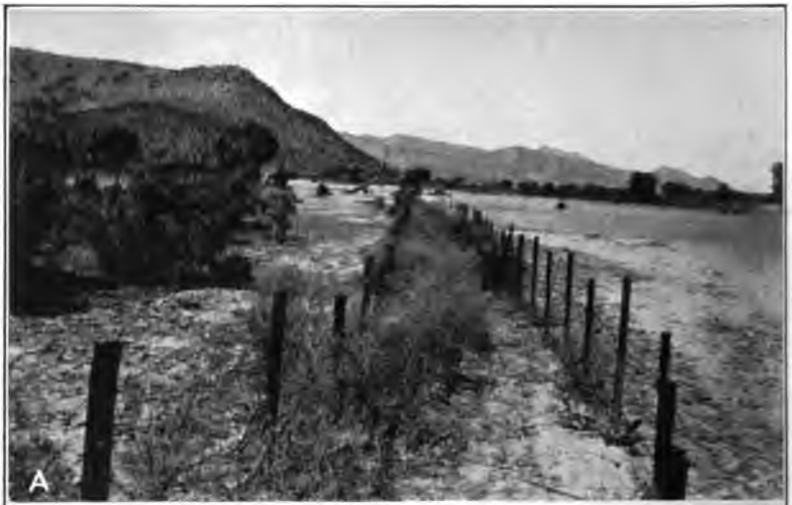
REDUCED PRODUCTIVITY OF RANGE LANDS

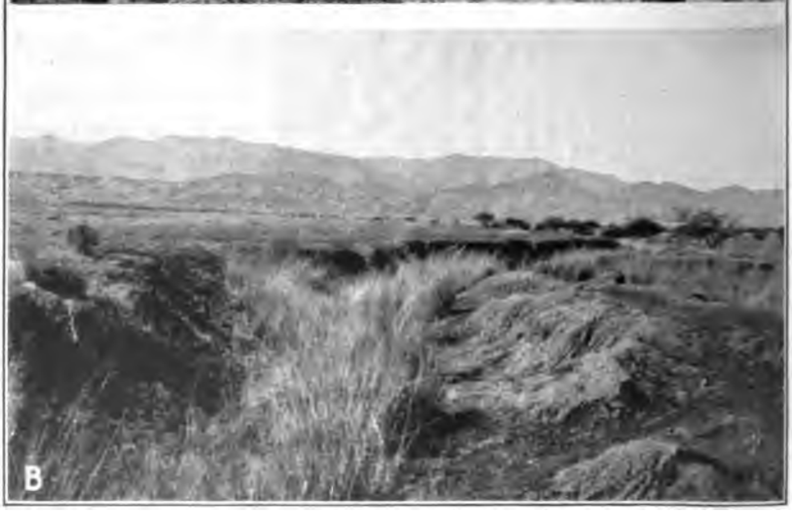
In the midst of such great destruction by floods and silting to valley farm lands, irrigation and other reservoirs, roads, bridges, and other public works, the excessive damage to the productivity of the range lands for livestock grazing has hardly been appreciated. In their original condition the slopes and valleys, except in those arid parts where rainfall was very light, were well carpeted with valuable grasses and a small percentage of other herbaceous and shrubby plants. The decaying vegetable matter had built up the surface soil into a friable condition and added to it a large quantity of rich organic matter. The mulch of decaying vegetable matter acted as a sponge, and the friable humic character of the soil allowed a maximum moisture penetration. The result was that the forage plants made the most of the rainfall and the fertile soil and produced abundantly.

When erosion removes the top layer of soil it robs the plants. If erosion continues, the soil may become incapable of producing the stand it once supported. The experiments at the Great Basin Experiment Station (*21*) showed that noneroded soil was much richer than eroded soil in lime, phosphoric acid, and total nitrogen; that the water-holding capacity was greater; and that the water required by representative plants to produce a pound of dry matter was less. A great many more leaves, greater stem and leaf length, and more dry matter are produced on the noneroded than on the eroded soil, even with a notably smaller supply of water. The conclusion was drawn that erosion is detrimental to plant growth chiefly because it brings about two conditions of soil impoverishment: (1) Lack of adequate soil moisture for full plant development and seed production and (2) lack of adequate plant nutrients in the soil for good growth. Furthermore, reestablishment of the vegetative cover is made more difficult.

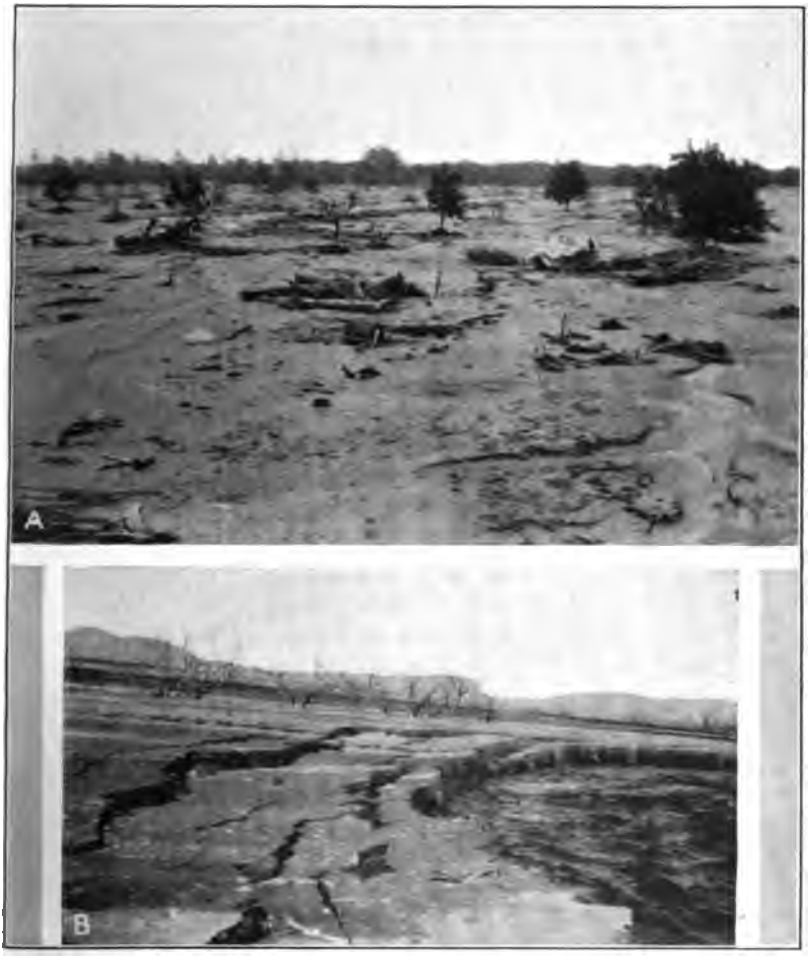


A.—Water accumulated in the wagon tracks and cut these gullies (Montana)
B.—Arroyo on Muddy Creek, Colo. The barn is about to be undermined

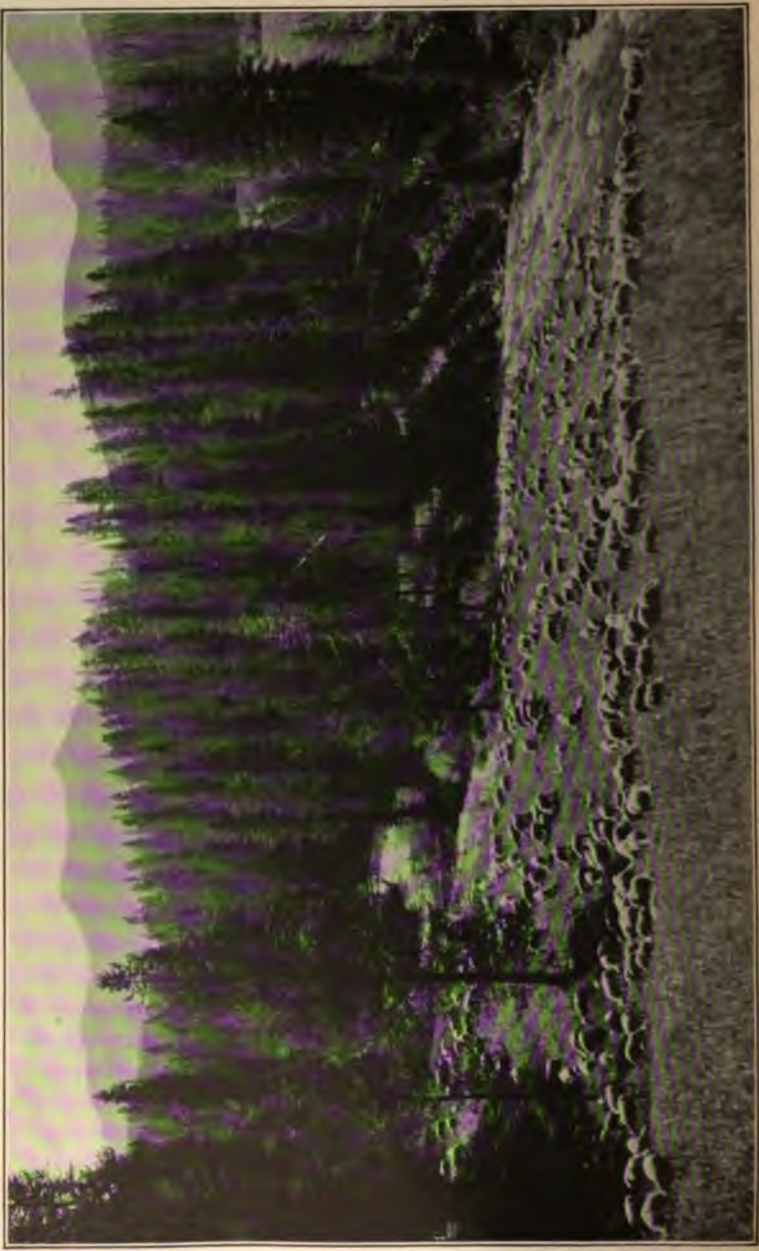




A.—Flood control fence constructed with iron posts to reduce velocity of flow, induce silting, and prevent bank cutting in a large drainage (Arizona)
B.—The establishment of grass in a gully tended to check further cutting (Arizona)



A.—Muck, driftwood, and other débris deposited in a young orange orchard by flood from hills made barren by fire
B.—Salt River, in slight flood stage, undercutting silt banks in the upper part of the Roosevelt Reservoir basin and carrying the mud down nearer the dam



Abundant excellent feed and a maximum of watershed protection (Montana)

Because of lowered moisture content from soil exposure and lowered water-holding capacity on eroded soil supporting a thin stand of vegetation, seed germinates poorly and many of the seedlings die.

In Montana W. G. McGinnies found that the blue bunch grass—sedge—weed type, the optimum herbaceous vegetation, normally covers 60 to 80 per cent of the soil surface and that but 2 acres of this cover are required to furnish a cow a month's feed. When the stand is thinned and the humus is washed out of the soil by erosion the valuable grasses give way and finally disappear, and plants of low value increase. Eventually, as the soil is depleted, rabbit brush—yellow brush—weed type, will take possession. This type usually covers but 20 to 40 per cent of the soil, and approximately 11 acres of it are required to furnish a cow a month's feed.

Numerous stockmen have remarked that the ranges of the West do not and will not carry as many animals as they once grazed. William Bailey, former tax commissioner of Utah, has stated that the "West Desert" of Utah will not support a tenth of what it once did. The reduced productivity of the ranges has increased the instability of the range livestock industry and made profitable production more difficult. Unless the number of livestock is reduced to conform to the smaller feed supply, the inevitable outcome is inadequate range feed, excessive death losses (particularly in drought periods), fewer calves and lambs, and decreased meat production. If the number is reduced, the per head investment in land and improvements may prove to be excessive.

WHAT NEEDS TO BE DONE

REESTABLISH THE VEGETATIVE COVER

This enormous wastage must be stopped. The problem is to determine and apply ways and means of checking the present extensive erosion, restoring the watersheds, preventing abnormal erosion, and obtaining permanent economic use of range land in the West. (Pl. 16.)

Of first importance is the effort to reestablish and conserve the optimum vegetative cover. Plants not only lessen the force of rainfall but intercept part of it. Vegetation improves soil structure, allowing greater moisture penetration; it increases the water-holding capacity of the soil by increasing organic matter; it breaks the effect of wind; it binds the soil and lessens sheet erosion; it obstructs run-off and reduces the velocity of flow and the carrying power of the water; and by catching soil particles it tends to form miniature terraces on slopes and dams and fills in small gullies. The more complete the plant cover, the more adequate is the protection against erosion.

If erosion is checked on a depleted area the vegetation present will gradually spread, slowly increasing the vegetable matter and plant foods in the soil. Short-lived species will be replaced by perennials and better soil-binding plants and, as the fertility of the soil is further improved, the more permanent type of perennial forage plants will become established.

The value of this in controlling erosion is indicated by the experiments on high mountain watersheds at the Great Basin Experiment

Station in Utah. After herbaceous vegetation had improved until it covered 40 per cent of the soil surface, the run-off from summer rains was 55 per cent less, and sediment eroded 56 per cent less than when the vegetation covered but 16 per cent of the surface. Run-off and erosion from melting snow appeared to be affected much less by the change in herbaceous vegetation. Though approximately 95 per cent of the annual run-off was from melting snow, it carried only 12 per cent of the sediment removed; the 5 per cent of run-off from summer rains carried 88 per cent of the sediment eroded annually. Thus, under the conditions prevailing in the experiment, the greatest need is for vegetation on the range to prevent the great erosion damage from summer rains.

Sometimes the range improvement is extremely slow, but every bit of progress helps not only in reducing erosion but in increasing the grazing value of the land. At the 1927 field day of the Great Basin Experiment Station it was shown that on an area on which the vegetation had been all but destroyed in 1903, the soil was so badly eroded and depleted that it had not yet built up to where it would support a stand of valuable forage species. Even so there had been a notable increase in carrying capacity. In 1927, 7.4 acres were required to support a cow for a month. On another area on which the stand of vegetation had been badly depleted but on which the soil was not so wasted, and adjoining a hillside where grass plants still remained under the protection of brush so that seed was available, a rather dense cover of valuable plants had become reestablished by 1927, and only 2.4 acres were required to support a cow a month. The greater part of this improvement has come in the last five years. The rate of improvement depends largely on the quantity of plants on the range which reseed or otherwise revegetate readily and on the methods of range management applied to aid recovery. In the Southwest rather badly depleted ranges can, with proper grazing, be reestablished, with three or four times as much forage as they are now supporting, in about five years.

The value of trees, shrubs, and grass for bank protection along small stream courses should be better appreciated, so that efforts will be made to protect them or to reestablish the stand if it has been destroyed.

REGULATE GRAZING

Stockmen are recognizing that conservative grazing keeps their animals in a good, thrifty condition throughout the year, increases the number of young produced, reduces death losses, and increases the weight and finish of salable animals, thus affording top prices and profitable production. Conservative grazing implies placing no more livestock on the range than the feed will support, and allowing the palatable plants to get enough of a start in the spring so that grazing will not impair their vigor. It also implies removing the livestock in the fall before the soil becomes so wet that trampling would injure it, unless the range and soil are of a character that allows yearlong use. A certain reserve of feed as an insurance against the ever-recurring drought is essential to assure sustained livestock production and watershed protection. Also, distribution of livestock over the range so as to obtain as even a use as practicable without undue concentration or trampling is important.

There are areas on which erosion injury is now occurring that could be greatly improved if grazed by a different class of livestock. This is true of certain rough mountain ranges where attempts to get full utilization of the feed on the range as a whole by cattle grazing is causing undue concentration in valleys and consequent erosion damage. Sheep would use the slopes to better advantage and could be more easily held off the damaged valley areas. Certain brush areas could be grazed more profitably by Angora goats than by the cattle and sheep now grazing there, bringing about improvement in the watershed and erosion conditions. Likewise, on some areas a change from sheep to cattle would prove desirable.

Deferred grazing or deferred and rotation grazing, which provides for reserving grazing from part or all of areas of range land until after seed maturity, although now widely applied, deserves more extensive use throughout the West. Other similar improved systems adapted to specific soil and forage types need to be devised or further developed so as to improve range lands without loss of use of the range forage. Experiments at the Great Basin station and on the Jornada and Santa Rita Range Reserves in the Southwest indicate that, except where the vegetative stand has been practically eliminated and the exposed soil is seriously eroded, the native cover can ordinarily be restored under properly regulated livestock grazing almost as well and as quickly as under total protection from grazing. Furthermore, the range can more easily be maintained at its best with grazing than without.

Some form of control of the unappropriated public domain is essential if it is to be restored. Most stockmen will agree that it should probably take the form of Federal regulation.

PROTECT THE COVER AGAINST FIRE

In recent years there has been a great awakening of the public to the need for fire prevention and quick suppression, especially in timber and brush lands. Most Western States have stringent laws regarding carelessness with fire, but, as brought out above, 336,000 acres of brush and grassland are burned yearly in California alone. The possible erosion danger should be carefully considered before fire is set with a view to improving the range. Under regulation, excessive grazing is sometimes practiced as a fire-prevention measure; but this in turn causes erosion, reduced feed values, and usually uneconomic livestock production. With depleted vegetative stands the fire danger is not great, but as the vegetation on range lands is improved for watershed protection it will be necessary to give more attention to fire protection.

AID EROSION CONTROL BY ARTIFICIAL MEANS

Artificial reseeding of range lands to known cultivated forage plants has not proved practicable except on areas with unusually favorable soil and moisture conditions. Tests are being made, however, of a number of species that show some promise. These tests deserve considerable expansion. In the meantime, management of the native vegetation so that it may serve to best advantage will be the main means of revegetating depleted areas. Of course, on important watersheds where the value of the stand is not alone determined by its grazing value it may pay to seed for erosion control.

Sampson and Weyl (*21*) found terracing and planting of steep, barren, eroded, high-mountain hillsides to native plants possible but costly. They urge such methods on areas that have eroded to such a point that natural revegetation is extremely slow and the vegetation present noneffective in binding the soil and in preventing erratic run-off.

Engineering works for the control of erosion have been used extensively in the mountain regions of Europe. Large dams for holding back flood crests or even for the catching of excessive silt have been established in a few places in the West. Check dams, small structures of rocks, logs, brush, or other materials, have also been constructed in the smaller stream channels, largely for the purpose of reducing the velocity of the water and thereby its carrying and cutting power. Such works are usually costly and unless they are supplemented with the maintenance of the highest type of vegetation the land is capable of supporting are apt to prove ineffective. As the importance of erosion control is recognized, however, engineering works, especially check dams, will doubtless come into greater use.

CONCLUSION

With erosion losses on western grazing lands so great, corrective action must be taken soon if far greater damage and more difficult control are to be obviated. Owners of range land should consider the use of their land not alone for immediate gain, but still more in the light of the future productivity of the range, the protection of water supply, and stream-flow regulation. Overgrazing should be stopped at once; control or regulation of the badly abused unappropriated and unreserved public domain should not be longer delayed by the Federal Government. Arroyo cutting must be checked by engineering works and the establishment of vegetation in the bed and on the sides of the arroyos. Range landowners, irrigationists, and the State and Federal Governments should band together to use every available means for checking erosion, floods, and inadequate water supply at their source, on the slopes, in gullies, and on small drainages of the watersheds. The Federal Government has a direct responsibility since Federal lands occupy such a large part of the West.

The main obstacle to action and one that has greatly delayed remedial measures has been lack of information as to the seriousness of the situation and as to concrete things which should be done under specific conditions. Without this information it is possible to work only in a broad way, rather than to attain a permanent control of erosion on range lands in a really constructive and economical manner. In view of the important part that herbaceous and shrubby vegetation play in controlling erosion of such lands it is essential that research determine just what is the optimum stand of vegetation that can be made to grow on the widely varying soil types and under the extreme climatic conditions of the West and the influence of this vegetation on water supply. It is equally important to know more concretely just what grazing use can be allowed under each of the main range and watershed conditions to assure profitable livestock production and a maximum of protection to the soil. Along these lines research is already doing its best to help the stockman and range landowner, but hardly more than a start has as yet been made. Faced with so big a problem, research needs the most earnest encouragement and support.

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GREAT INLAND WATER-WAY PROJECTS IN THE UNITED STATES

Mississippi Valley Flood Control

The St. Lawrence Water-Way from Lakes to Sea

Boulder Dam

Muscle Shoals

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Basic Factors in Flood Frequency in the Lower Mississippi River

By Lewis F. Thomas, Ph.D.
Associate Professor of Geography, Washington University, St. Louis, Missouri

ARE great floods becoming more frequent in the Lower Mississippi River? In terms of volumes of water involved, the answer is no, since the fundamental physical causes of these floods are substantially unchanging. In terms of dollars in losses, the answer is yes, since the economic development of the areas affected is progressively becoming more valuable. The greatness of a flood may be expressed in various ways, (1) by the size of the areas inundated, (2) by the value of the economic losses sustained, (3) by the height of the gage readings, and (4) by the volume of the waters discharged. The records of the United States bureaus show that there have been notable floods in the years, 1815, 1828, 1844, 1849, 1850, 1851, 1858, 1859, 1862, 1865, 1867, 1874, 1882, 1884, 1890, 1893, 1897, 1903, 1912, 1913, 1916, 1922 and 1927. Since 1871 careful and detailed flood records have been kept at all strategic flood points in the Mississippi Basin. Because of the data available, the floods subsequent to 1871 have been studied individually and collectively. The floods prior to 1871 are known only in a general way through the compilation of data from numerous and miscellaneous sources. A resume of the general conditions which exist in the Mississippi Basin gives the setting of flood causation.

The Mississippi River Basin

The Mississippi Basin comprises some 1,250,900 square miles which are apportioned among its major divisions as follows: Upper Mississippi River 172,000 or 14 per cent, Missouri River 528,850 or 42 per cent, Ohio River 203,900 or 16 per cent, Arkansas River 186,000 or 15 per cent, Red River 90,000 or 7 per cent, and Lower Mississippi River 70,150 or 6 per cent.

The Upper Mississippi River is about 1200 miles in length. It has as its important tributaries the Leach Lake, Crow Wing, Minnesota, St. Croix, Chippewa, Wisconsin, Rock, Illinois, Iowa, and Des Moines rivers. The headwaters of the rivers which rise in northern Wisconsin, upper Michigan, and northern Minnesota wind in circuitous courses through lakes, swamps, and bogs in the timbered morainic hills of sand and gravel. These features tend to check rapid run-off and as a consequence few floods arise from this region. The prairie portions of the Upper Mississippi Basin are in southern Wisconsin, southern Minnesota, eastern Iowa, and northern Illinois. The once vast tree dotted grasslands are now productive with abundant farm crops, and numerous livestock.

The Missouri River, which is formed by the confluence of the Jefferson, Madison, and Gallatin rivers, in the southwestern part of Montana, flows 2824 miles in a southeasterly direction to join the Mississippi River a few miles above St. Louis, Missouri. Its principal tributaries are the Milk, Marias, Sun, Yellowstone, Grand (South Dakota), Cheyenne, White, Niobrara, Platte, Kansas, Osage, Grand

(Missouri), and Gasconade rivers. The few of the rivers which rise on the eastern slopes of the Rocky Mountains are fed from springs, lakes, and snow fields of that region. The major portion of the Missouri Basin lies in the semi-arid Great Plains. Here the streams are sluggish, turbid, full of shoals and islands, and bordered by easily eroded banks of sand and clay. On the flood plains fields of irrigated crops have replaced the sickly fringe of cottonwoods and willows which once lined the water courses. On the wide gently undulating interstream areas ranching prevails with some dry farming. The tributaries of the lower Missouri Basin drain the western portion of the Corn Belt, or the northern slopes of the Ozarks. The rivers of the Corn Belt section in eastern Nebraska, eastern Kansas, western Iowa, and northern Missouri have numerous tributaries which have carved the uplands into belts of gently rolling hills or flat-topped ridges. The northern slopes of the Ozarks are maturely dissected hills whose steep rocky sides favor swift streams, rapid run-off and sudden floods. The basin of the Gasconade River is typical.

The length of the Ohio River from Pittsburg, Pennsylvania, to Cairo, Illinois, is 965 miles. The headwaters, the Allegheny and Monongahela rivers, together with the tributaries Licking, Muskingum, Little Kanawha, Great Kanawha, Big Sandy, Kentucky, Cumberland, and Tennessee rivers drain the wooded rugged, rocky hills of the Appalachian Plateaus. The clearing of some of the forests together with the steepness and completeness of surface drainage provide conditions favorable for sudden rises in these rivers in periods of heavy rains. Other important tributaries to the Ohio River are the Scioto, Miami, and Wabash rivers. These rivers in western Ohio, Indiana, and eastern Illinois (the eastern Corn Belt) are similar to those in the western Corn Belt.

The Arkansas River rises in central Colorado, in the Rocky Mountains. After passing through the Royal Gorge, it emerges on the Great Plains; crosses eastern Colorado, southern Kansas, northeastern Oklahoma, and central Arkansas; and empties into the Mississippi River in southeastern Arkansas. In its 1610 miles, it resembles the Missouri River features. Its headwaters are clear on a bed of pebbles and rock. In the Great Plains section, the Cimarron and Canadian tributaries add their contribution of mud and quick sand to that of the Arkansas. The lower Arkansas flows through a region rich in agriculture of the plantation type where cotton and rice predominate. The most volume is added by the White River which rises in the rugged hills of the Ozarks and Boston Mountains.

The Red River is about 800 miles in length from its sources in west Texas to the Lower Mississippi in Louisiana. Its flow through much of its course is scanty and precarious, since it is dependent solely upon immediate run off from rains. In its lower course it fares better in a region of more abundant and regular rainfall.

The Lower Mississippi River extends from the mouth of the Missouri River to the passes at the Gulf of Mexico. About half of the basin is alluvial floodplain type comprising some 30,000 square miles. These plains are about 600 miles in length, but the river meanders through a course exceeding 1100 miles. The surface has a very low gradient which combined with the oxbow lakes, sloughs, and bayous, and with the timbered sections favors very slow run-off of precipitation. Prior to the building of levees and the organization of drainage districts much of the basin was subject to inundations and as a consequence lay idle. Since these projects have been completed large sections are cultivated and devoted to cotton growing. It is this basin that suffers most from floods in the Mississippi River system.

OCCURRENCE OF SEVERE FLOODS

The comparative severity of floods is usually determined by levels reached by the various floods on the same gage. By way of illustration, the gage at the mouth of White River, Arkansas, may be selected as typical of readings along the Lower Mississippi River. The gage is located 391.7 miles below Cairo, Illinois, and has its zero at 108.86 feet above mean Gulf level. The highest annual minimum is 14.20 feet, while the majority of such readings are below 7.00 feet. The flood stage at this station is 48.00 feet. The years when floods attained or exceeded this mark are: 1862, 48.20; 1882, 48.40; 1883, 48.00; 1886, 48.20; 1890, 50.40; 1892, 49.27; 1893, 49.48; 1897, 52.42; 1898, 51.05; 1899, 48.49; 1903, 53.70; 1904, 49.50; 1906, 49.80; 1907, 51.90; 1908, 49.50; 1909, 49.95; 1911, 48.33; 1912, 56.35; 1913, 55.35; 1916, 56.50; 1917, 51.57; 1919, 49.38; 1920, 53.10; 1922, 56.85; and 1927, 60.25. It is quite apparent that there is a tendency toward higher and higher readings culminating in the record breaking flood of 1927. An examination of other Lower Mississippi River stations reveals similar trends.

Further survey of the flood data shows that stations on the major tributaries have their record maximum in different years, and that even on the same tributary stations may have had the records set in different years. On the Upper Mississippi River, these gages recorded their maximum as indicated; St. Paul, Minnesota, 1881; Winona, Minnesota, 1880; Rock Island, Illinois, 1892; Burlington, Iowa, 1851; Nashville, Iowa, 1888; Hannibal, Missouri, 1903; St. Louis, Missouri, 1844. On the Missouri River, the record maximum was made at Kansas City, Missouri, in 1844, and at St. Charles, Missouri, in the same year. On the Ohio River, the records were broken at Pittsburg, Pennsylvania, 1907; at Cincinnati, Ohio, 1884; at Louisville, Kentucky, 1884; at Evansville, Indiana, 1844; at Paducah, Kentucky, 1913; and at Cairo, Illinois, 1927. On the Red River at Shreveport, Louisiana, and on the Arkansas River at Little Rock records were set in 1927.

The area of the overflowed land has varied during the various great floods due to the holding, extension or breaking of the levees. Before 1880 the Lower Mississippi River had practically free, open, and unrestricted channel conditions, so that the areas flooded by severe floods were about the same each time: 29,790 square miles. Beginning in 1880, there has been progressive extension, raising, and strengthening of levees. By 1916 the river was practically canalized from Cairo to the Gulf. The effects of this levee building have been more pronounced than the figures indicate, because the flood marks at stations below Cairo, Illinois, have been changed to meet the new conditions several times since 1896.

Contemporaneous with the building of levees has occurred a general shrinkage in the area flooded as is indicated: 1897, 13,580; 1903, 6,820; 1912, 17,605; 1922, 13,200; and in 1927 when the levee system collapsed, estimated 15,000 to 18,000 square miles. The losses may be classified as, (1) property losses exclusive of crops, (2) crop loss and damage, (3) damage to farm lands, and (4) losses occasioned through enforced suspension of business. The estimated losses for 1897 were $15,000,000 for agricultural damage. In

1903 a total of $40,000,000; in 1912, $78,000,000; in 1922, $17,087,790; and in 1927 about $285,000,000 in losses. Such losses even though they be rough estimates cause one to ask: How often must these losses be borne?

FREQUENCY OF SEVERE FLOODS

Attempts have been made to reduce the question of flood frequency to a mathematical basis. One set of calculations has been prepared for the Lower Mississippi River. Selecting New Orleans as typical it is illustrated by the number of ordinary floods per decade from 1871 to 1922, thus: 7, 10, 9, 6, 7, total 39. The frequency for severe floods at the same place and period is: 1, 1, 3, 3, 5, total 13. Vicksburg, Mississippi, and Memphis, Tennessee, show similar series. The expectancy or average interval in years between ordinary floods has been computed as 1.33 at New Orleans, 1.30 at Vicksburg, and 1.37 at Memphis. The similar expectancy for severe floods at the same places is respectively, 4.00, 3.06, and 5.20. The lack of correlation which is noticeable between the ordinary and severe floods is due to the fact that ordinary floods may be and frequently are caused by high waters in a single tributary, particularly the Ohio River, while severe floods are usually the result of high waters in two or more tributaries. The fact that the tributaries do not have high waters at the same time, except rarely, was shown by the data above for the years breaking records.

The flood frequencies of the major tributaries further show the lack of coincidence of high waters. This is shown for ordinary and severe floods (latter marked *) as follows: the Ohio River at Cairo, 1.33 and *2.08; the Upper Mississippi River at St. Louis, 2.74 and *10.40; the Arkansas River at Little Rock, 1.41 and *5.78; and the Red River at Alexandria, 3.80 and *38.00. Thus it is evident that the chances of high waters occurring at the same time on all the major tributaries is rare. The last flood, 1927, was the nearest approach. Moreover it appears that there is a close relation between the floods of the Ohio and the Lower Mississippi rivers.

CAUSES OF FLOODS

Students of the floods assert that the Ohio River is by itself capable of producing severe floods in the Lower Mississippi River. And so another set of calculations has been made to determine the frequency of floods in the Ohio River. It appears from a study which correlates precipitation data and flood occurrence data in this basin that there is no evidence of increasing frequency of floods. It does demonstrate that there is a cause and effect relation between the precipitation features and floods. Thus, there was a rainfall deficiency in the Ohio Basin during the decade 1870–1880 which would account for the lack of floods of any noticeable size in that period. In 1881 to 1883 there was a large excess in rainfall which accounts for the great floods of those years, culminating in the record gage reading of 71.07 in 1884. Then followed a period of deficiency with no floods. In 1890 there was a local excess in the lower Ohio Basin which tallies with the flood in that part of the valley. Then drought followed, and no floods resulted until 1897; then a couple of years of heavy rains with corresponding floods; a term of dry years to 1906, then rains and floods in 1907. Similar studies concerning the Upper Mississippi River and lower Missouri River show conclusively that precipitation conditions are competent to produce the floods, and that the floods are as irregular in occurrence as precipitation conditions are fickle. Hence a review of the general conditions in the Mississippi Basin with regard to precipitation will aid in understanding the factors of flood frequency.

Normally there is scanty precipitation over the western and northern portions of the Mississippi Basin in January, February and March. At the same time rainy conditions prevail over the southern Appalachians. During April and May precipitation reaches its greatest amount over the West. In June two rainy centers appear: one in the Lower Mississippi, and the other in the lower Missouri basins. In July and August, rainfall diminishes in the West and becomes uniform over the Lower Mississippi Valley. September, October, November and December successively approach winter conditions with light precipitation over the West, and intense heavy downpours over the lower valley in December. The character of the ground, whether frozen or water soaked, has a great deal to do with the percentage of run-off from these precipitation conditions.

It has been estimated that about twenty-seven per cent of the precipitation in the Upper Mississippi Basin finds its way to the rivers and amounts to about 230,130,000,000 cubic yards of water. The early summer rains and winter scantiness result in a single swell reaching its height in June and declining to August, with marked low water levels to late January when the swell begins again.

In the Missouri Basin about fifteen per cent of the rainfall reaches the rivers and gives a normal discharge of about 131,230,000,000 cubic yards of water. The Missouri minimum occurs in December and rises to a minor swell in May which is followed by a major swell in June, after which the river level falls rapidly to a December minimum.

The Ohio Basin receives the most abundant and well distributed precipitation of all the component basins. This with its thirty per cent run-off totals about 230,130,000,000 cubic yards of water which makes it rank first in volume among the tributaries. The Ohio River normally because of winter rains in the Appalachians, has high water in March. Its low stages come in October.

The Mississippi River regimen below Cairo is the composite of the combined swells of its tributaries. The main swell of the Ohio River reaches Cairo about the middle of April, having risen rapidly. The ebbing of the swell is checked by the rising swells from the Upper Mississippi and Missouri rivers. Hence the swell below Cairo consists of one long sweeping rise for six months and one long decline of similar length. The heavy rains over the Lower Mississippi Basin at times aggravate the normally high waters into flood conditions.

The Arkansas River discharges about fifteen per cent of its precipitation amounting to about 74,070,000,000 cubic yards of water. The Arkansas River is low in August and high in May. Its swell normally has no effect upon the regimen of the Mississippi River.

The Red River with its annual discharge of 66,670,000,000 cubic yards of water, representing about twenty-two per cent of its rainfall, has a range similar to the Arkansas with similar lack of normal effects.

It may be noted again that the timing of these various swells from the major tributaries, considered from the standpoint also of their geographic location, gives a rhythmical succession of increments which normally results in harmless high waters. However, normal conditions do not always persist. In every case the floods can be traced to excess discharges from some one or more basins.

The actual discharges of water in a few of the great floods 1882, 1903, 1912, 1913, 1915–16, 1920 and 1922 according to calculation each exceeded 159,000,000,000 cubic yards. For example, the flood of 1882 was made up as follows: Ohio River, 107,868; Upper Mississippi River, 30,693; Lower Mississippi River, 68,005; Missouri River 25,826; and Red River 24,874 making a grand total of 272,137 in millions of cubic yards of water. This flood which is rated as an exceptionally severe one is typical of the kind produced by a great discharge from the Ohio River basin. The flood occurred early in 1882. During the months of January, February and March when the above discharges occurred, there was an excess precipitation over the southern half of the Ohio Basin and Lower Mississippi Basin, and over the lower Arkansas and Red basins ranging from 8 to 12 inches excess.

In 1927 all the rivers south of the Des Moines River were in excess discharge, with excesses ranging from six to nine inches in Iowa to twenty-three inches in the middle Arkansas Valley. The nearest approach to such conditions in the recorded past occurred in 1922 when there were excesses over the lower Ohio and Mississippi basins in February, with a spreading of excess conditions to the northward over the lower Missouri and lower Upper Mississippi basins by March. The total discharge of this 1922 flood is estimated at 265,146,000,000 cubic yards of water. The evenness of the distribution of excess is shown as follows: Ohio River, 81,115; Upper Mississippi, 31,410; Lower Mississippi, 52,658; Missouri, 39,589; Arkansas, 31,410; and Red, 27,962 millions of cubic yards of water.

The flood discharges for the other floods listed (in millions of cubic yards) are: 1882, 272,137; 1903, 200,786; 1912, 239,774; 1913, 228,759; 1915–16, 170,049; 1920, 159,196; 1922, 365,146. These figures give some notion of the immense volumes of water which pass down the Mississippi River at flood times. As a measuring stick, the normal river flow past St. Louis, Missouri, is estimated at 225,000 cubic feet per second. It is stated by observers at Little Rock, Arkansas, that the Arkansas River ran at 813,000 cubic feet per second during the 1927 flood.

CONCLUSIONS

It may be concluded:

I. That the basic factors of severe floods causation are uncontrollable.

II. That the frequency of severe flood occurrence is a function of precipitation and varies irregularly as the amount and distribution of precipitation varies.

III. That the engineering problem is to regulate the flow of flood waters and prevent the inundation of valuable lands.

IV. Supplementary, that such engineering works should be designed to conserve the features of the rivers adapted to waterpower, navigation, water supply, and sanitation.

The Geography of the Mississippi Valley

By Frank E. Williams
University of Pennsylvania

When Daniel Boone returned from one of his hunting and exploring expeditions, he was more than usually extravagant in his praises of the area he had just visited—that reached by passing westward through the famous Cumberland Gap. Here was a land described as rich in growth of all those hardwoods which show unusual fertility in the soil. The region he had seen was a part of the now well-known Blue Grass Region—a basin rich in agricultural development. But the Blue Grass Region, although one of the richest, is only a speck in that larger area of high fertility and gentle topography which reaches from the Alleghanies to the Rockies and is for the most part contained in the Mississippi Valley.

The Great Mississippi River and more than fifty navigable tributaries furnish about 14,000 miles of waterways and border or traverse twenty-seven states whose combined area is 1,935,952 square miles (65 per cent of U. S.). Of these twenty-seven states, seventeen are entirely or very largely within the Mississippi Drainage System. The importance of this great inland empire is unappreciated by most, only partly recognized by a considerable number and fully known to but few. Here is one of the best farming regions of the world, and when it was opened to the growth of the cereals New England and much of other Eastern areas went "down and out." In this area of the Mississippi Valley a little over half of the people of the United States live. Here is 65 per cent of the improved land of the nation. Here is produced about 85 per cent of the country's crop of corn, 65 per cent of the wheat, 78 per cent of the oats, and almost 50 per cent of the cotton. Here also are raised about 65 per cent of the horses, 60 per cent of the dairy cattle, while 55 per cent of the beef cattle, 80 per cent of the hogs and 45 per cent of the sheep of the nation are made ready for the market. Here are obtained about 75 per cent of our bituminous coal, a considerable portion of the iron ore, over 50 per cent of the lead and over 50 per cent of the zinc. This area is also growing rapidly in manufactures and if the lake cities are included now produces almost 50 per cent of the country's manufactured articles.

Topographic Features

Most of this great area which is so rich in resources is without striking topographic features. It is generally level or gently rolling, occasionally hilly, but never mountainous. Much of it appears as a limitless expanse of grove-dotted, gently undulating country, here and there trenched by rivers and surmounted by low hills; or it stretches away as far as the eye can see without either of these relief features—a grass-covered, farm-dotted, smoothly contoured prairie. North of the Missouri and Ohio Rivers it is glaciated. Morainic belts cross it in looped pattern, and between them are notably flat till plains. In that portion covered by glacial ice in the last (Wisconsin) glacial invasion, lakes, ponds, and undrained hollows in great numbers are scattered freely about, stream courses are disorganized, falls and rapids abound and alternate with swampy depressions often of considerable extent. Most of the area, however, is well drained and well fitted for agriculture. This is shown by the great number of evenly spaced comfortable houses and big barns.

From north to south almost through the center of this area flows the mighty Father of Waters. This great stream, although at times a devastating curse to many inhabitants of the valley, has been of great importance in opening up the country to settlement and has borne many millions of tons of produce to market.

This great valley and its river system present a twofold problem. It has low-water difficulty as well as a high-water peril; it involves keeping navigable depths in the channel as well as keeping navigation off the riparian corn and cotton fields; it associates intimately the interests of navigation and conservation. It is, then, the problem of keeping the system in shape to carry river commerce and of controlling its disastrous floods.

RIVER COMMERCE

Although the lower river is still important as a commercial highway its value to the people of the valley was much greater in the past. New Orleans was established in 1718, but for a decade before this the river had been used as a carrier for furs and for lead from the easily worked mines along the river in Iowa and Wisconsin. By 1740 there were about 2000 farmers along the river in Illinois whose only outlet for their produce was the river. It is true that the early Western settlers could send over the mountain to the Eastern markets the valuable articles of little bulk, such as furs, ginseng or whiskey, or the livestock which could be driven to market. For carrying their flour, pork, tallow, leather and lumber to market they used keel boats and barges.

The steamboat made its appearance on the Ohio River in 1811 and by 1817 had been improved so that it could cope with the currents of the Mississippi and other interior rivers. With further improvements, the steamboat became important by 1822 and river traffic developed rapidly up to 1846 when the output of the lead mines began to decrease. The lead was beginning to go east via the Great Lakes and Erie Canal because the cost was less. The river boats had been having great difficulty especially at the rapids at Rock Island and at Keokuk, which at low-water stages in summer and fall were almost impassable and which often necessitated the reloading of cargoes into barges of light draft which were towed over the rapids with horses.

From 1840 to 1855, in spite of the difficulties of the rapids, etc., the boats reaped a rich harvest because of the large numbers of settlers going into Iowa, Wisconsin, and Minnesota.

The period 1858–1870 is the period of railroad competition, at first helping river commerce, later destroying it.

This period also saw the development of a new type of carrier, the grain barge, towed by steamboats. These were extensively used for about ten years, but about 1870 the railroads had penetrated the grain growing section, and the grain barges soon became almost useless.

Fifty years ago there were 470 steamboats plying regularly on the Mississippi. At the present time, you would have a hard time finding forty-seven, even if you were to count a few government snag and dredge boats to make up the total. In the spring a few big coal tows descend the stepping stones of the Ohio from Pittsburgh to Cairo, and then on down the main river to the gulf. Near Vicksburg, Memphis and Baton Rouge, a few steamboats come and go on local routes over the waters. Now and then a lone towboat shoving a barge ahead of it disturbs the desolation of the Missouri (once the only artery to the West), and occasionally dwellers near the banks of the Arkansas or Red Rivers hear the whistle of a laboring stern wheeler as she paints their blue skies with a black smoke. River commerce of the present time is of relatively slight importance and along much of the river is largely confined to excursion steamers and sand barges. In fact, the channel is such that after August 1, a boat of six feet draft has great difficulty getting up to St. Louis on the lower river and a boat drawing but four feet of water can only with great difficulty get to St. Paul.

REASONS FOR DECLINE OF RIVER TRANSPORTATION

Two generations ago the Mississippi and its main tributaries were alive with water traffic. Now there is almost none. What are the reasons for this decline? There are several. The Civil War blockade of the lower river by the Confederacy, temporarily stopped down river traffic and helped the railroads in their lead over the river boats, a lead which was not reversed after the war because most of the trade in this section naturally moves east and west, not north and south, and when once started in its natural direction, if even by a temporary cause, is not easily changed. At the close of the Civil War, cheap slave labor to man the boats and load and unload them disappeared. Discriminatory rates by the railroads were also a factor, but the outstanding cause for the decline of the river traffic is that the steamboats could not compete with the new carrier, the railroad, not only in freight costs but also in several other ways. River traffic is limited to a certain natural route. Railroads can be built anywhere. There is no closed season for railroads and their traffic is regular throughout the year, while the farmer who attempted to ship by boat could not tell when to have his stock or produce at the river bank and the yards and storage facilities at the landings were either not there at all or very unsatisfactory. Another factor which was important in causing trade to leave the boats and go to the railroads was the variability of the boat freight rates. In one case the rate during high water was 25 cents per 100 pounds and the low water rate was $2.50 for the same distance.

Also, the difficulties of maintaining a channel are great. There were recently 43 sand bars below Cairo, each with an average length of about 800 feet. At low river stages these come up to within four or five feet of the surface. On the tops of them lie dead trees, anchored by their matted, uptorn roots. These are the bars and the snags, which obstruct navigation at low water. Because of them, big fleets of government snag boats and dredges are maintained. There are 18 high bridges and 25 drawbridges between St. Paul and the mouth of the Missouri River, which also hinder navigation. From New Orleans 110 miles down to the Eads Jettie at South Pass, the river is 100 feet deep, and for 300 miles up river from New Orleans there is sufficient depth for navigation at low water, but the remaining 600 miles to St. Louis requires constant dredging to maintain even an eight-foot channel such as has been done for several years. The 180 miles from Cairo up to St. Louis is one of the worst sections of all.

DESCRIPTION OF THE MISSISSIPPI

We have briefly discussed the use of the river, let us now see what it is like. The source of the Upper Mississippi is in north central Minnesota in a region which is sprinkled with a multitude of small lakes, and is close to a slight swell of land which separates it from the waters of the Hudson Bay. These lakes lie in a wilderness of evergreen woods and tamarack marshes, of low-lying hills and ridges left by the northward retreating glacier. From a physiographic point of view, the river flows through a valley representing three types of formation. From its source to Minneapolis, the river flows through a shallow or "young" valley. Leaving the small Lake Hernando de Soto through an almost indiscernible outlet, its waters flow through alternate lakes and marshes and over many rapids and falls until it plunges over St. Anthony into the gorge below. In this course of the river, many artificial dams have been built, thus adding to the storage capacity of the natural reservoirs.

Below Minneapolis is found the second part, which extends down the river 888 miles of its course to Cairo, Illinois. For this part of its length, the river flows in a gorge varying from one to six and a half miles in width and with bluffs rising from 100 to 650 feet above the river. These bluffs are not continuous like the Palisades of the Hudson or like the Niagara River Gorge, but stretch along the river on either side "like lines of giant sentinels." This is the part of the river noted for its beauty — "majestic bluffs that overlook the river, along through this region, charm one with the grace and variety of their forms, and the soft beauty of their adornment. The steep, verdant slope, whose base is at the water's edge, is topped by a lofty rampart of broken turreted rocks, which are exquisitely rich and mellow in color — mainly dark browns and dull greens, but splashed with other tints."[1]

Below Cairo, the valley is a level flood plain 50–100 miles wide, with much of this area below water level of the river at high stages. Beginning as it does but 1500 feet above sea level, in the 2555 miles of descent to the Gulf, the river can average a fall of less than six inches per mile. It makes more than half of this descent in the 600 miles from its source to St. Paul, and for the rest of its journey (1950 miles) it falls only three or four inches per mile. With a low gradient goes a low average velocity; nevertheless, the Mississippi River carries down and empties into the Gulf of Mexico every year about 400 millions of tons of mud. To transport this mud by rail would require 500 trains of 50 cars each hauling 50 tons per car, working every day in the year. Thirty-one per cent of the water of the Lower Mississippi is contributed by the Ohio River, 19 per cent by the Upper Mississippi and only 14 per cent by the Missouri, but with the 14 per cent of water of the latter, comes 60 per cent of this silt. The Mississippi River, a few miles above St. Louis at the mouth of the Missouri River, is one and one half miles wide, but from this junction to the mouth of the Ohio, it narrows to about three-quarters of a mile in width. This great tributary seems to diminish the width of the main stream, but as perceptibly increases its depth and volume and alters its character.

DIFFICULTIES OF DOCKING AND NAVIGATION

The Mississippi River, then, is very different from one of the type represented by the Delaware or Hudson. Instead of tides of from five to eight feet which do not seriously interfere with docking or navigation, on the Mississippi River we have stages varying through a range of 54 feet between high and low water at Cairo, Illinois, and almost as much at many other cities. At a point about a mile below this city in the extreme southern point of Illinois, the Ohio, normally about a mile wide, and the Upper Mississippi, half a mile wide, flow together. The river, especially from this junction down, which is really the trunk line portion of the system, is made up of a series of wide curves, and loops which are called oxbows. When the narrow strip of land, between the upstream and downstream sides, of one of these loops is washed away, the river takes a short cut and leaves a crescent shaped lagoon or bayou. "These cut-offs have had curious effects: they have thrown several river towns out into the rural districts, and built up sand bars and forest in front of them. The town of Delta used to be three miles below Vicksburg; a recent cut-off has radically changed the position and Delta is now two miles above Vicksburg."[2] In another part of his book, Mark Twain states that, "In the space of one hundred and seventy-six years, the Lower Mississippi has shortened itself two hundred and forty-two miles." Using this as a basis of computation, he rather facetiously writes: "Any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen." So crooked is the river's course that, although the channel distance from Cairo to the Gulf is 1200 miles, the air line distance is only half as far. Instead of rock as is found along the banks of a river like the Delaware or Hudson which affords good foundations for factories and wharves, the Mississippi's banks, especially along the lower part of its course, are fine sand, silt or gravel, which almost dissolves when it gets wet. From St. Louis to Cairo, bed rock (within the gorge) averages 50–150 feet below water level, while below Cairo it is much deeper down. There are, therefore, almost no factory sites on the water front on the Lower Mississippi and wharves are hard to build and maintain. The discharge of a river like the Delaware or Hudson remains relatively constant through the year, while that of the Mississippi River varies from about 70,000 cubic feet per second at low water to 2,300,000 at high water stages.

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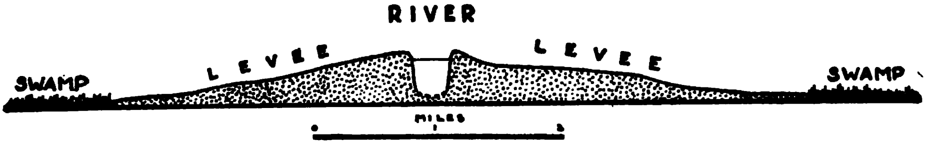
[1] Twain, Mark, "Life on the Mississippi." Harper & Bros.

We must keep in mind that the material upon which the river is flow-



PROFILE OF THE MISSISSIPPI RIVER AT BELLE POINT

ABOUT 50 MILES ABOVE NEW ORLEANS. SHOWS NATURAL LEVEES AND HOW WATER WOULD POUR OUT INTO SWAMPS ACROSS THE OCCUPIED AREAS ON THE LEVEE SLOPES IF A BREAK SHOULD OCCUR. (VERTICAL SCALE EXAGGERATED) ing was carried there by itself or its tributaries. Sediments brought by the streams from the higher lands were deposited and gradually the alluvial flood plain was built up. The coarsest and heaviest sediments were deposited first along the borders of the stream and the finer material was carried out and deposited farther away. Continued deposition of this type following repeated overflows causes the land to be built up rapidly near the streams and slowly in the inter-stream areas so that the surface is highest near the river and gradually slopes away from it (see profile). This accounts for much of the poorly drained areas away from the river and the early settlement along the slopes and natural levees, while the back areas were still unoccupied. The material of the natural levees being unconsolidated is very easily eroded.

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[2] Twain, Mark, "Life on the Mississippi." Harper & Bros.

DANGER CAUSED BY CHANGES IN THE CHANNEL

On every one of the many turns and bends throughout the whole 1200 miles, the river is constantly undermining and wearing away the outer bank of the channel in much the same way as the outer rail of a curve on a railroad is worn rapidly and must soon be replaced. The fine-grained, loose character of the soil, greatly facilitates the undermining action, especially during the irresistible rush of flood waters.

This habit of eating away its banks is perhaps the worst thing which can be charged against the Lower Mississippi, and presents one of the most serious problems in the whole question of control. Needless to say, the unceasing changing of the course is vitally important to the plantation owner, who sees his fertile land steadily vanishing, often at the rate of 400 or more feet a year along his entire water front. It is still more important to the towns and shipping points located along the river. New Orleans is the only big city located directly on the river flat, and, fortunately for the city, it is at a place where the river's course is now comparatively straight. Other cities, like Memphis, Vicksburg and Natchez, are located on the high bluffs where the river swings close against the eastern side of its valley. These latter towns have secured immunity from floods, but even simple changes in the channel would deprive them completely of their water fronts and strike fatal blows at their prosperity.

Even the present extent of the river traffic demands that there shall be more or less villages directly along the river and steamboat landings at various points, but every one of these places enjoys only a temporary existence. Since the river current hugs close along the outer side of every curve in its course, it follows that the deepest water, and hence, the main channel, also lies near the outer bank. The natural result is that all steamboat landings and all important shipping points must be located on the outer banks of curves, as is found to be the case all along the river. The difficulty which lies therein is obvious enough, for with rapid undermining of the outer bank of all bends, the river is always tending to destroy the water front of every place so situated. The history of the landings below Cairo shows that practically every one of them has been driven back before the advancing river at the rate of 100 to 150 feet per year for the last quarter of a century.[3]

Much money and time have been spent on attempts to keep the river navigable. Trees and snags are removed; loose, slipping banks are protected by revetments of willow, boards or other material; and wing dams are built in order to narrow the

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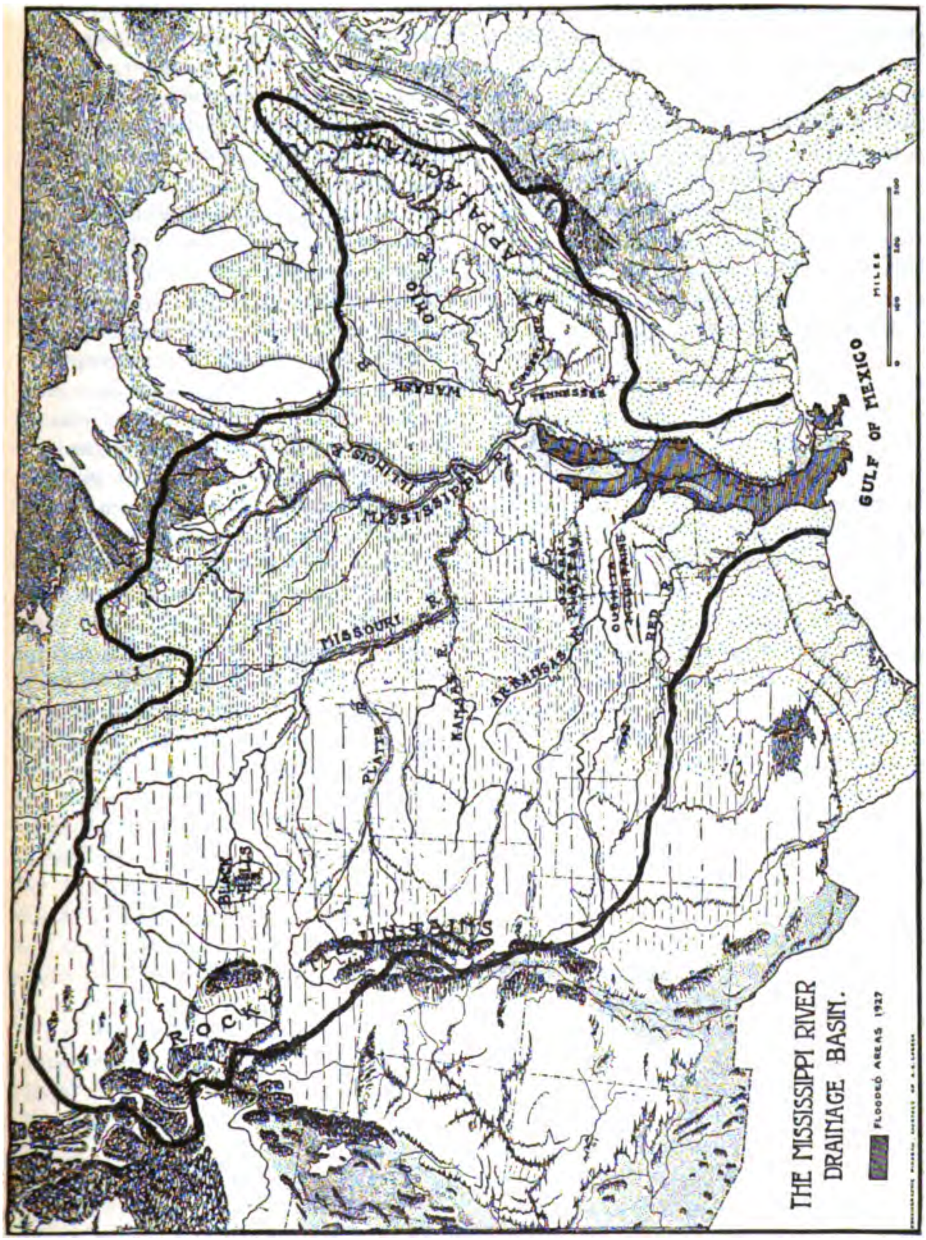
[3] Tower, W. S., "The Mississippi River Problem"; Bulletin of the Philadelphia Geographical Society, Vol. 6, 1908, p. 87.



THE MISSISSIPPI RIVER DRAINAGE BASIN.

channel and cause greater depth in the Ohio and Upper Mississippi. These have proven only partially successful. There are many who believe that the Mississippi River will again become a great highway of commerce and argue for a 14-foot channel from Chicago via the Illinois River and the great river to the Gulf. A barge line was started in the summer of 1927 on the Mississippi above St. Louis. It will be some time before we can predict success or failure for this and other traffic programs planned to renew transportation on the river and its tributaries.

FLOOD CONTROL

The second great problem of vital interest to those living on the flood plains of the Mississippi and its tributaries is that of flood control. The great flood of 1927 — the most distinctive of all — was one of some fifteen very serious floods that have occurred in about 50 years. Fernando de Soto's party found the river at flood, and many seasons of high water have been known since, notably those of 1785 and 1844. Although the people who live in the valley of the Mississippi have many valuable resources, they also have a continental climate, usually changeable, but sometimes very erratic. Untimely rains, combined with melting snows or a long period of wet weather, followed by heavy rains over much of the valley, cause high water in the flood plain areas.

It should be emphasized that the area affected by floods is only a small part of the Mississippi Valley (shown by accompanying map). It is advocated by many that parts of the area so often submerged and so sparsely populated should be abandoned and all efforts be combined on attempts to protect the more populous and prosperous areas. If loss of life can be prevented, this would seem logical, for there is no more reason to ask the Government to protect an area subject to overflow and whose owner takes a chance than to ask that same Government to protect from drought or frost. However, the Mississippi is the great drainage artery of the Mississippi Valley and as such must ever be of great interest to the inhabitants of most of the area between the Alleghany and Rocky Mountains.

The Improvement of Our Mid-West Waterways

By Hon. Herbert Hoover[1]

Secretary of Commerce

IN the past three years I have addressed many in support of further development of our inland waterways. In fact the Secretary of Commerce is enjoined by the organic act creating that office to foster and promote the development of transportation. It is a subject that can interest only the serious-minded, for any contribution to public thought must be by economic reasoning, not by oratory.

I am concerned with this improvement because it will contribute to the wealth and economic progress of every section of the Union. It will contribute to the unity of the nation. It is of concern to every one of our millions of farms and homes. The Mississippi Valley Association, representing all parts of the Mid-West, has been long devoted to the promotion of flood control and inland waterways; it has a record of great accomplishment. But the work is far from complete, and that work and mine requires that we should formulate and support plans not only for tomorrow but with vision of the distant future, for the day is here when we must look to the welfare of not alone 115,000,000 Americans of our generation, but we have a responsibility toward the 150,000,000 Americans who will be living in our children's time.

Mississippi Flood Control

The most important event in our national life during the past year has been one which bears directly upon the development and control of our great rivers—that is, the Mississippi Flood. Sad and heartrending as it has been in its human aspects, severe and discouraging as have been the economic losses, it at least serves to bring home to the American people the increasing dangers to a growing population which lurk in our great streams if they be not adequately controlled.

I had the honor to be chosen by President Coolidge to organize and direct the relief activities which were supported so generously by our Government and the people at large through the Red Cross. No man could occupy that responsibility and have witnessed its scenes without being deeply moved to the human necessity of immediate and final prevention of its ever recurring again.

I have little need to dwell upon the causes of the great flood and its destruction. But there is an aspect of the flood that has perhaps not been sufficiently emphasized. The destructivity of this flood was partly due to the rapidly increasing settlement of the flood area. This increase will continue, and such dangers to our country will increase as years go on unless we establish adequate controls. The great delta of the Mississippi River, which in reality extends from Cairo to the Gulf, has been for untold centuries the spillway for our interior rivers. They spread their annual floods over these richest of alluvial lands for a thousand miles long and from 20 to 150 miles wide. With the pressure of population, our people have, more especially in the past quarter of a century, invaded the flood region. With courage and resolution they have overcome the swamp and forest, they have converted it into homes and productive farms. And in so doing, they have of necessity crowded out the annual floods with peace until finally they have forced the river in flood time to confine itself to its own channel.

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[1] An address before the Mississippi Valley Association, St. Louis, Missouri, Monday evening, November 14, 1927.

Seldom do we reprint addresses in *The Annals*. But this address is too good to miss.—C. L. K.

I need not recount to you that, with the unprecedented volume of water of this year, these barriers crumpled up and the river spread itself again over its old flood area. Some 750,000 of our people were compelled to flee their homes in jeopardy of their lives. Damage to their farms and villages amounted to hundreds of millions.

Such a flood 25 years ago would have wrought far less destruction simply because there were fewer people and less property in its track. If we look into the future but a quarter of a century, we can envisage even far greater dangers than those past. We may not have so great a flood again for many years to come. But the richness of these soils and the pressure of our growing people will some day see 5 or 10 million of them settled under these levees. No one can contemplate these millions of our fellow citizens living in such jeopardy without adequate and final protection.

I believe the whole of the United States is unanimous in that we must undertake such engineering works as will give security—not only now but for the future. Our people have arrived at this conclusion because of their warm sympathy for the welfare of their fellow citizens. But, viewed from the more narrow point of view, the destruction of property is the loss of the entire nation—it is not solely the loss of the individual sufferers. The loss of several millions of acres of crops in this flood deprived the American people of just that much goods which they might have otherwise consumed or exported, and again every worker and every farmer in our country to some degree was a loser through the decreased buying power of flood sufferers themselves. Every investor in railways and industry of the South lost something.

Our able engineering staff under the leadership of General Jadwin will in a few weeks have consummated their plans by which these floods can be controlled. And it devolves upon my colleague, Secretary Davis, to present them to Congress as the basis for legislation.

I am confident of the outcome that we shall as a nation within the next few months have taken such action as will not only give assurance of safety to the whole of our fellow citizens in the flood territory, but that will give such security as will guarantee the continued development of this great region.

INLAND WATERWAYS

But, in our necessity to remake and energetically construct such flood control works as will guarantee protection against these calamities, we must not be diverted from our march to the improvement of our inland waterways. That is as important to the suffering flood states as it is to our people elsewhere. Indeed, we have made great progress in the past year in this great improvement of our national estate, both in actual construction and in advancement of public support.

It is perhaps unnecessary to recount that every great national development in transportation must pass through many stages. There must be a situation to be remedied, there must be compelling cause for action; there must be a determination of the remedies that are available; there must be a definite plan conceived; the works must be constructed; and finally they must be used.

THE SITUATION TO REMEDY

The urgency of the situation to be remedied, to a large degree, grows from the economic shifts due to the war which have brought a new setting to all our mid-Continent. The necessarily large advance in our railroad rates as a result of higher wages and cost of materials since the war serves to set a row of tollgates around the Middle West. There is thus a charge, new with the war, against all goods coming into the Mid-West and all goods going out. It is not as if all parts of the country and all parts of the world had been placed under a similar tax, for that is not the case.

You will find that ocean rates have returned to a prewar basis—and thus the folks of seaboard countries do not pay these additional tolls to and from market, and therefore they have today a greatly increased competitive advantage over their fellows in the interior. This, together with the completion of the Panama Canal, the full effect of which was not evident until after the war, all combine to distort the economic setting of this whole Mid-West.

Mid-West agriculture and Mid-West industry have been placed in a new relationship to different parts of our country and to the world markets as a whole. If we would restore these former relationships, we must find fundamentally cheaper transportation for our grain and bulk commodities which we export and the raw materials which we import into the Mid-West.

I can possibly make this problem of economic shifts more clear by example: a great part of the agriculture which competes with our farmers lies to a considerable degree in Argentina, Australia, Eastern Europe and India. Those agricultural areas are all nearer to seaboard and their ocean rates to the common markets remain the same as prewar, while our rail rates to seaboard on wheat, for instance, have increased about 8 to 18 cents per bushel. Therefore foreign farmers reach European markets at a less cost in proportion to prewar than can our Mid-West American farmer. In actual figures, the competing farmers from the Argentine, for instance, have felt an increase in rates of only 2 cents per bushel.

I believe there is general agreement that the cost of transportation is a deduction from the price the farmer receives at the world's markets—and besides that the price at which he realizes his surplus in foreign and seaboard markets makes the price of his whole product at home, so that the effect of increased transportation rates to these markets is far greater than the bare amount as applied to exports only. It is an enormous sum when applied to our crops and is one of the contributing causes of the farmer's postwar difficulties. It is not all the farm problem, but it is a substantial part.

While the Panama Canal has carried great benefits to our people, we cannot ignore the fact that it has also contributed to distort the competitive relationships of the Mid-West and our seaboard business and industry. It has drawn the East and West seaboards much closer together by greatly decreasing transportation costs and therefore tends to draw an area of Pacific's business formerly enjoyed by the Mid-West toward the Atlantic States. We can roughly visualize the combined effect of the canal and higher rail rates if we set up a new measuring unit in the shape of the number of cents which it takes to carry a ton of staple goods at present rates. Using that measuring rod and taking the cheapest routes, we find that before the war New York was 1904 cents away from San Francisco, while now it is only 1680 cents away. But a given Mid-West point, which was 2600 cents away from the Pacific Coast before the war, is today 3114 cents away. In effect this Mid-West point has moved 514 cents away from the Pacific Coast while New York has moved 224 cents closer to the Pacific Coast. A similar calculation will show that in the same period this Mid-West point has moved 694 cents away from the markets of the Atlantic seaboard and South America.

All this causes certain types of Mid-West business to migrate to seaboard. It steadily tends to establish manufacture nearer to seaboard and farther from the heart of agriculture, to the mutual disadvantage of both. It likewise has a tendency to limit the area of Mid-West wholesale distribution. Individual merchants and manufacturers in the interior can give you many instances of it all.

From all this serious shift in economic currents in its effect on agriculture and upon business we surely have something worthy of our best effort in remedy. And remedy lies as I have said in finding cheaper transportation in bulk products of agriculture and in raw materials.

THE REMEDY

With the higher cost of labor and materials, we cannot expect any consequential reduction in our railroad rates without ruin to that vital circulating system. Our railways have reached the highest efficiency in their history, and we must maintain them in that condition. We cannot close the Panama Canal. Nor can we raise Atlantic Ocean and other sea rates, because the standards of living in the rest of the world, unlike our own, have not increased over prewar, and therefore the cost of operating foreign overseas shipping is not far from a prewar basis.

In any examination of our country for remedy, we have naturally turned to a consideration of the magnificent natural waterways which Providence has blessed us with. It is therefore our conception that we should deepen our rivers to permit modern barge transportation, deepen the outlet to the Great Lakes to permit ocean-going shipping, and to connect them all together into a definite transportation system.

THE PLAN

Your Association has for long years steadily fostered and forwarded the development of inland waterways. But the national mind perhaps, until in the past two or three years, has conceived waterways development as local projects of some immediate near by improvement, instead of in the wide vision of a comprehensive system of 12,000 miles of connected inland water transportation reaching from the Gulf to the Northern frontiers and from the Lakes to the Atlantic Ocean.

The plan can be simply stated:

It is to deepen the 9000 miles of the Mississippi and its tributaries to minimum depths of 6 to 9 feet so as to permit modern barge service—that is, the Mississippi system.

The construction of the St. Lawrence shipway from the Lakes to the Atlantic, thus opening every lake port to the vessels of the world over 3000 miles of deep waterways—the Great Lakes system.

There are other important waterway improvements of less size which bear directly and indirectly upon the Mid-West. The stabilization of lake levels and deepening of the channels so as to permit full ship loading within the Lakes, the intracoastal waterways and the continuous development of our harbors are all works which must go forward some time but are not our particular subject tonight.

During the last year we have made

great steps in progress of these plans and in the consummation of some of them. Congress has authorized the remaining unfinished links in the Mississippi system. It has increased appropriations available to $20,000,000 per year for their execution. If these appropriations continue we should see the improved Upper Ohio linked with the Lower Mississippi in another two years. We should see the Missouri steadily deepened to Kansas City and as far above as traffic warrants. Already barge navigation has begun upon the Upper Mississippi to St. Paul and Minneapolis. I am in hopes that in not more than five years we shall see Chicago connected to the Mississippi and thereby with the Gulf by a nine-foot channel. By these works and the gradual improvement of channels up the other tributaries as traffic warrants, we shall at last replace a series of disconnected segments of river improvements into a great transportation system.

Curiously enough, I find that some of the press in outlying parts of the country still have the lingering notion that we are trying to restore the romantic steamboatin' days with gay river steamers whistling down the reaches, with possible Mark Twains aboard. I am not adverse to romance when it can be had without cost to the taxpayers. What we are trying to do lacks that color, but carries much more freight. What we want is to deepen our streams so that they become unfailing channels for flocks of steel barges, shepherded by puffing tugs. It lacks splendor and the glorious adventure of the olden days, but each flock will carry at a single trip from 4000 to 16,000 tons—more than say fifty old-fashioned packet boats or more than five modern freight trains. It is no doubt the drab toil of modern commerce, but in this bulk and in this mobility of units which can be sent to different destinations do we realize modern river transportation and modern mass handling of commodities on our inland water.

Two years ago I was able to promise that this traffic and these benefits would flow as soon as we had connected up the segments of this great Mississippi system. But in so short a time as two years the demands upon even the disconnected segments have grown beyond the capacity of our equipment and already we begin to see a complete confirmation of our assurances. Last year over 10,000,000 tons of commodities moved on the Lower Mississippi and nearly 20,000,000 tons upon the Ohio. The present gap in the connection of these great segments is just as if a stretch of narrow gauge line were introduced into the New York Central main line.

Recent delegations of shippers to Washington showed that there are hundreds of thousands of tons more unable to move because of insufficient equipment on the river—and we must bear in mind that we have not yet felt the effect of the fully developed system for such great centers as Kansas City, Chicago, Pittsburgh, Cincinnati, and Louisville and their hinterlands are not yet connected either with each other or with St. Louis, Memphis and New Orleans.

This should settle once and for all the contention of our critics that there was no demand in goods to be moved upon the rivers.

A component part of our inland system is the Great Lakes. In them we have the mightiest inland waterway given to any continent. They bore last year over 115,000,000 tons of traffic.

But the full influence of the Great Lakes system in remedy to the economic difficulties of the Mid-West is dependent on the deepening of the channel of the St. Lawrence River to permit deep-sea shipping from the Great Lakes into every port of the world. The consummation of such an undertaking would represent the final step in 150 years of battle for the removal of barriers in this great waterway to the Mid-West. It would give an effective outlet for eighteen of our states to the North Atlantic.

The Joint Board of Engineers have submitted to their two governments their report upon this work. Their conclusions were that this route is the most beneficial and efficient one, by large margins the cheapest to build and operate. In accord with the compelling interpretation of the facts, our American Commission, of which I have the honor to be chairman, has recommended that its construction be undertaken.

Some months ago we requested the Canadian Government to enter these negotiations. However intricate the questions may be which are involved in these international relations, I am confident that they can be solved upon the ample foundations of broad mutual interest and good-will which have signalled our two nations since our birth. We have for a century coöperated with each other in constant improvement of this great highway. It has been part of our joint endeavor in the development of the new civilization on this Continent. This final step is a task worthy of the strength and purpose of the two sister countries who have in two centuries already overcome countless obstacles in implanting the most helpful civilization of history.

THE OPPOSITION TO WATERWAY DEVELOPMENT

You will find three main schools of opponents of the vigorous development of our water transportation—first, those who doubt that it will yield the economic benefits which we assert; second, those who feel that it implies undue burdens upon our taxpayers; and, third, those who fear that these developments might injure our magnificent railway system.

The question is whether anyone of all of these projects are justified. We are no longer on theoretical grounds when we assert that Mid-West transportation of bulk materials will be cheapened by these means. We have the actual beginning of experience. During the past year we have seen the Government barge line operating successfully upon the St. Louis-New Orleans segment with a rate down river on wheat about 8 cents a bushel less than by rail, and a rate up river on imported commodities of as much as 10 cents per hundred pounds less than by rail. During the past few months we have seen the barge line extended to St. Paul and Minneapolis, 12 cents per bushel lower by water than by rail, and we have seen the up river rates on coffee and sugar 16 cents per hundred pounds less than by rail.

While we can point to these benefits, we shall not come into full realization of these services even on the Lower or Upper Mississippi until we have completed the other segments of the system. It is only then that we shall have diversified our traffic, established reserves of equipment, felt the benefits of private enterprise, which will give us the full values of cheaper transportation costs.

I believe that the statement often made that, by the modernization of the Mississippi and the Great Lakes systems of waterways, we shall decrease the freight on grain to the world markets by 10 cents a bushel is not far wrong. And by so doing, we should increase the price of all grain to the farmer by 10 cents per bushel, and this 10 cents is the profit end of the price. One single year of such increase to our Mid-West farmers would more than equal the entire capital outlay which we propose. I doubt if since the days when we transformed transportation from the wagon to the railroad have we seen so positive an opportunity to assist the prosperity of our people.

As to those who complain of the capital cost upon our taxpayers, it may be recalled that no great engineering projects can be consummated in a year. The completion of these projects are spread over from two to ten years, even if they were all authorized tomorrow. I dare say the whole of our water transportation projects I have mentioned could be accomplished with an increase in our present annual expenditure upon rivers and harbors of 20 millions a year. That a nation with an annual income of 90 billions can undertake to spend a tenth of one per cent of its national income in such works requires little argument. Upon this point we can do no better than quote the most successful statesman in economy in our national history—President Coolidge—who in his last message to Congress said, in referring to these very projects: "Expenditure of this character is compatible with economy. It is in the nature of capital investment."

Another criticism to which I have given great consideration is that the opening of these great waterways would endanger the stability of our railway system. Taking the country as a whole, the railways must ever bear the major burden of our goods traffic. And there are many classes of goods which will always go by rail even parallel with the waterways. And here is an old saying that is true: "New transportation facilities create business." It is well proved by our new highways.

At one time in our history we practically abandoned the highways and waterways for the railways. The invention of the gas engine has restored our highways and multiplied their traffic ten thousandfold. Yet the total volume of passengers and goods on our railways has increased threefold in 25 years; the next quarter of a century promises even a larger addition to our population than the last 25 years. The railways must provide for the major burden of this increase, and I believe most railway operators agree that our railways can well be supplemented in their provision for this increased traffic by fully developed waterways. I have no fear for their prosperity.

NATIONAL ORGANIZATION

There must lie before us constantly the necessity to so organize these projects as to accomplish them with rigid economy and high efficiency. I am convinced that we have come into an entirely new era in the development of our water resources and therefore we should give thought to the whole basis of our governmental organization which bears upon control and execution of these developments, if we would have economic and efficient execution; if we would confine ourselves in rotation to the works most urgently needed; and if we would do justice by private enterprise and our taxpayers. One of our difficulties in the past has been to secure well-thought-out plans and policies in the development of our multitude of different water resources. And even when plans have been adopted we have incurred unpardonable wastes of money through lack of continuity in action. We need public understanding that appropriations for these projects must go through to completion or that they should not be undertaken.

Another of our problems requiring immediate consideration is the increase of equipment upon the river. We need to develop this question in such fashion that it shall ultimately be taken over by private enterprise because in the long run it is through private competition only that we will have efficient use of the waterways. The Government undertook to pioneer the equipment for a modernized river through the barge line. The pioneering stage is not over and may not be over for some time. We must devise ways and means of larger equipment and devise the program for its ultimate taking over by private enterprise.

A further problem presents itself in that modern investment and our increase of population have introduced many new and complex factors into the planning and construction of some of these water improvements. So long as we are concerned solely with improving navigation upon our streams, the organization and administrative problems are comparatively simple. It is a function assigned to the Federal Government and administered by one Federal agency—the Corps of Engineers. But today on many of our streams we have other problems besides navigation. There is flood control, reclamation and irrigation which will loom even more largely 20 or 30 years hence when we shall want more land. We have problems of water distribution and water rights and domestic water. Beyond this, private agencies are engaged in electrical power development under government permit.

The most casual study of this subject will show that every different river in the United States has possibilities of development in from one to five of these particulars. Often enough these different interests conflict. The unit of development must be a drainage basin if we are to secure the full values from these our noblest resources.

Now if you will study our Federal and State governmental agencies that have authority in these questions, you will find a most appalling lack of coordinated action. In our Federal Government relations to these problems of navigation, flood control, power, domestic water, reclamation and irrigation lie in four separate agencies of the Government. You will find that within our State governments we deal with these questions by from two to five different agencies. You will find also that county and district organizations —many of them—have authority on these questions.

Beyond this you will find that often enough from two to twenty states are interested in a single drainage. In other words, I have found it possible to compute that as many as thirty different independent governmental agencies may be interested in the development of a single drainage.

There is at times bitter conflict between these agencies, and between states. I could take much of your time illustrating the friction which has grown up—the litigation which fills the courts and the conversion of these technical problems into politics with all of its inability to solve what are fundamentally engineering questions. We have in many cases abandoned the pouring of cement in order to pour out our emotions.

I need cite no greater instances than the Colorado River, the Chicago drainage diversion and even the Mississippi Flood, because the sacrifice of flood control to reclamation has been one of the contributory causes of that disaster.

I am not one of those who believe that we should ruthlessly uproot institutions, services and relations between our states and the Federal Government in order that we may attain a paper perfection in plans of organization. What we really need is that we should build within these agencies the necessary links of coördination in such manner as will maintain both our local government and national responsibility yet secure the coördinated development of each drainage.

Two years ago I made a tentative suggestion upon which every event since that time has brought further confirmation as to its necessity. That was that we should create separately upon a half dozen of our great drainages, where multiple problems occur, advisory commissions on which not only the various branches of our Federal Government should be represented, but that the time has come when the State governments concerned should be represented and where necessary local authorities should also have a voice; that it should be the duty of these advisory commissions to determine broad policies upon which the development should take place, that they should develop plans by which the different agencies of navigation, flood control, power, reclamation and irrigation and domestic water should proceed; that they should determine the economic urgency of the different segments of such plans. We have already in the Mississippi and St. Lawrence Commissions a start upon this basis of organization the former having to do with flood control alone.

I am not proposing any additional engineering staff. The material already collected and the large number of surveys ordered by the last session of Congress are a long stride toward the full provision of technical data. I do not propose that the new commissions should have any administrative authority—their only task should be to present the plans they formulate to Congress, to the states and to the public at large. Once our legislative bodies have taken action, then the task of construction and operation should be left to responsible departmental agencies or private enterprise and not to boards or commissions.

These administrative suggestions are not proposals for centralization of government but decentralization; they are not proposals to displace the authority of Congress, but to assist an already overworked body; they are not proposals of more than trivial expense, but safeguarding from the waste of hundreds of millions in ill-planned development and loss of our full water resources.

CONCLUSIONS

I have stated on another occasion that the consummation of these beneficent projects are the greatest engineering undertakings of our history. They are more than that—they are undertakings worthy of the effort of mighty nations. There is nothing that so lifts the spirit, the ideals and the faith of a people as confidence in their ability at great undertakings and the proof of this ability through fine achievement. It is the sort of display of national might and greatness which advanced courage of men. There is nothing that should so appeal to the imagination of our people as the rediscovery of the resources of our continent through the application of the great tools science has given us. It is a sore need of the vast inland empire whose populations have a right to every contribution that can be made to their welfare and their prosperity. In the distribution of recovery from the war, our industrial sections have been more fortunate than the agricultural sections and their situation needs be met with no narrow spirit.

The development of our waterways will enlarge the wealth and income of all our people, will make for better homes and happier lives. It will further consummate that fine promise in the Constitution "to create a more perfect Union."

And, finally, I may again recall a statement of President Washington in recounting one of his pioneering journeys to this same Mid-West. He said this: "Prompted by these actual observations, I could not help taking a more contemplative and extensive view of the vast inland navigation of these United States, and could not but be struck with the immense diffusion and importance of it, and with the goodness of that Providence, which has dealt her favors to us with so profuse a hand. Would to God we may have the wisdom to improve them."

If we in our generation have so great a vision as the Father of Our Country we shall do it.

The Report of the Committee on Mississippi Flood Control Appointed by the United States Chamber of Commerce

By Frederic A. Delano
Chairman, Washington, D. C.

THE salient points of this Committee's report and its conclusions are:

(1) To begin with, the Committee attempted to make a catalogue of the floods which have occurred in the last 200 years. During 150 years of that time, one must depend upon somewhat indefinite historic records, accurate enough, however, to indicate that as often as every ten years or so these floods were very serious. Since 1879, the year the Mississippi River Commission was created, precise data have been available. These show that there have been in the last fifty years seven floods in the main river which were serious enough to be characterized as important.

(2) The seriousness of these floods and the resulting damage have satisfied the Committee that the work of protection has been inadequate either in its conception or execution. In trying to satisfy itself upon this point, the Committee came to the conclusion that a work of such magnitude must be under a centralized control with a single responsibility for its maintenance as well as construction. It has been stated without contradiction that even in this last terrific flood, no levee constructed under the present specifications of the Mississippi River Commission has given away; that the levees which have given away were levees which were either faulty in construction, inadequate in height and strength, or were not so protected with revetment as to withstand the terrific onslaught of this flood. The lack of centralized control has naturally led to waste, so that not only have the communities greatly suffered in each flood period, but much of the work that had been done has been thereafter largely undone.

(3) It became evident to the Committee that the work of control, adequately conceived and properly centralized, must be undertaken on a continuing basis. The commission undertaking the work must approach the subject as any great engineering construction must be undertaken, as, for example, the Panama Canal. A general method of dealing with the project must be agreed upon, the work must go forward and funds be made available on a progressive basis. Because the work requires in some cases special and heavy machinery, contracts must be let, the execution of which will require at times two or three years. In no other way can we deal with so great a problem either effectively or economically.

(4) A difficult angle of the problem presented itself when the Committee considered the limitations of the work which it was ready to recommend to Congress should be undertaken solely by Federal authority. The Committee's recommendation that the work should be under Federal control has already been explained, but the justification for that recommendation lies largely in the fact that the lower

Mississippi River (between Cairo and the Gulf) drains the water from thirty-one states. This part of the river may be termed the *main trunk line sewer* for 60 per cent of the area of the continental United States. It is so none the less because it receives a large precipitation within its own immediate drainage area. This vast drainage system cannot be considered as a local matter, and yet if you undertake to enlarge it by demanding that the control of the Federal Government shall include some of the tributaries, for example, the upper Mississippi, you at once get into trouble, for there is no more reason why the Federal Government should protect the upper Mississippi River in which five states are involved, than it should protect any other interstate stream. The same is true of the Ohio River, the Missouri, the Arkansas and the Red River.

(5) It was evident that a serious flood in the lower Mississippi River not only operated to destroy commerce upon the River itself for a considerable period of time, but what was far more serious, it destroyed interstate commerce by rail and highway along the River and across the valley over a very wide extent of country.

(6) Finally, your Committee strongly recommended in its report that the work of flood control should be considered by itself, not associated with any other projects however meritorious; that it should be put in the hands of a highly competent commission, with the most competent engineering staff available. Incidentally it should be said, this is not in any sense a criticism of the Mississippi River Commission or of the Engineer Corps of the Army, both of which have done excellent work with conditions and limitations what they were.

With this explanation it will be readily understood why the Committee made to the Chamber four major recommendations which are now being considered in a letter ballot by the entire membership:

I. That the Federal Government should hereafter pay the entire cost of constructing and maintaining works necessary to control floods of the lower Mississippi River. (For purposes of this report from Cairo to the Gulf.)

II. That the Federal Government should assume the sole responsibility for locating, constructing, and maintaining such works.

III. That there should be an adequate appropriation to insure efficient, continuous and economic work, the funds to be available as needed.

IV. That flood control of the Mississippi River should be dealt with in legislation and administration upon its own merits, separate and distinct from any other undertaking.

The report of the Committee[1] follows:

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[1] The members of this Committee were as follows:

PERSONNEL OF COMMITTEE

DELANO, FREDERIC A., *Chairman:* Engineer, of Washington, D. C.; formerly a railroad executive and president of the Wabash Railroad; appointed a member of the Federal Reserve Board upon establishment of the Federal Reserve System, resigning in 1918 to enter Army; on staff of the director general of transportation in France; recently receiver for the United States Supreme Court in Red River Boundary Case.

LAMONT, ROBERT P., *Vice-Chairman:* Manufacturer, of Chicago; president, American Steel Foundries; director, First National Bank of Chicago, Armour and Company, etc.; during war, chief, procurement division, Ordnance Department; member, Chicago Association of Commerce, and

THE COMMITTEE REPORT

To the Board of Directors of the Chamber of Commerce of the United States:

Your decision to appoint this special committee was made at a time when the Mississippi River was in the midst of one of its most destructive floods. The interest of the American people was at its height, and the fullest measure of sympathy was being extended to the stricken people in the Mississippi valley. All means of aid were being considered and organizations were being perfected to extend such aid and give relief. It is inferred from the wording of the resolution passed at the annual meeting of the National Chamber in May, dealing with conditions arising from the Mississippi River flood, that any phase of this problem which the committee might consider appropriate for Chamber action should be studied.

The immediate and generous response of the American people to the President's appeal for funds has, under the very prompt and efficient work of the American Red Cross in the relief of suffering, prevented epidemics and furnished food and shelter to the people whom the flood suddenly bereft of their homes, cattle, and other possessions.

Before the flood waters had begun to recede, steps had been taken toward rehabilitation.

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formerly vice-president, Illinois Manufacturers Association; director, Chamber of Commerce of the United States.

BENT, ARTHUR S.: Engineering contractor, of Los Angeles, California; senior partner, Bent Brothers, and president, California Glazed Cement Pipe Company; formerly president, Associated General Contractors of America; director, Chamber of Commerce of the United States.

BUTTERWORTH, WILLIAM: Manufacturer, of Moline, Illinois; president, Deere and Company; formerly president, National Implement and Vehicle Association; vice-president of the Chamber of Commerce of the United States for the northern central states.

COUCH, H. C.: Engineer, of Pine Bluff, Arkansas; president, Arkansas Light and Power Company; vice-president, Bankers Trust Company, Little Rock, Arkansas; chairman, Arkansas Farm Credit Company; national councillor for Pine Bluff Chamber of Commerce in United States Chamber.

DICKINSON, JACOB M.: Lawyer, of Chicago; formerly Secretary of War, president of the American Bar Association, receiver for Rock Island Lines, etc.; vice-president, American Society of International Law.

ELLIS, ROBERT R.: Wholesale merchant, of Memphis, Tennessee; president, The Hessig-Ellis Drug Company; formerly president, Memphis Chamber of Commerce; vice-president of the Chamber of Commerce of the United States for the southern central states.

HINES, WALKER D.: Lawyer, of New York City; president, Cotton-Textile Institute; formerly chairman, board of directors, Atchison, Topeka and Santa Fe Railroad; formerly Director General of Railroads; recently arbitrator under Peace Treaties of questions relating to river shipping and investigator under League of Nations respecting navigation on Rhine and Danube.

LONSDALE, JOHN G.: Banker, of St. Louis, Missouri; president, the National Bank of Commerce, St. Louis; director, St. Louis Reserve Bank; member, Commerce and Marine Committee of the American Bankers Association; director representing Finance Department, Chamber of Commerce of the United States.

MEAD, DANIEL W.: Engineer, of Madison, Wisconsin; professor of hydraulic and sanitary engineering, University of Wisconsin and consulting engineer in these fields; member of the former Red Cross Commission to China on flood protection and formerly consulting engineer, Miami Conservancy District.

PARKER, JOHN M.: Cotton planter and cotton merchant, of New Orleans; former Governor of Louisiana; formerly president, New Orleans Board of Trade, Mississippi Valley Association, etc.

PERCY, LEROY: Lawyer and cotton planter, of Greenville, Mississippi; former Senator of the United States; director, St. Louis Federal Reserve Bank.

SLOAN, MATTHEW S.: Engineer, of Brooklyn, New York; president, Brooklyn Edison Company; member, American Institute of Electrical Engineers; director, Brooklyn Chamber of Commerce; director representing Natural Resources Department, Chamber of Commerce of the United States.

STONE, ALFRED H.: Cotton planter, of Dunleith, Mississippi; vice-president, Staple Cotton Cooperative Association.

The Honorable Herbert Hoover, Secretary of Commerce, whom the President had placed at the head of the government's field activities, had organized efforts in this direction. He was receiving a large measure of assistance from the banks and other financial interests of the country, working directly with him or independently through organizations which they had initiated. The work of rehabilitation received further impetus through the Flood Credits Corporation,—the organization of which was brought about through the efforts of the National Chamber.

FLOOD CONTROL

Measures of immediate relief having been put into effect, and the lines of economic rehabilitation established when your committee was created, the sole remaining problem which has commanded our attention has been that of arriving at "a program which will insure, so far as is humanly possible, a permanent solution" of floods of the Mississippi River.

Almost fifty years ago the federal government became actively engaged in Mississippi River work through the creation of the Mississippi River Commission. The repetition of floods since that time has impressed more and more strongly upon business interests of the country and the general public the national character of this flood control. This statement is supported by the following quotations from "Bradstreets" published April 17, 1897, exactly thirty years previous to the recent flood: "The attention which the subject of Mississippi River overflow is receiving at present is certainly not out of proportion to the vast interests, both human and financial, which are involved, and it seems encouraging to note the practical agreement that whatever is to be done, whether in the strengthening of the present levees or the devising of new and more efficacious plans of controlling the river, should be under national direction."

The committee has been impressed with the insistant demand throughout the nation that the recent flood should not go the way of other floods and be merely recorded in history as "the record flood of 1927," but that it should be remembered as the flood which aroused the nation to its sense of responsibility and directed the forces which will ultimately prevent a repetition. Our present wealth, our increasing national solidarity, the interdependence of various sections of the country, the increasing importance of our great arteries of commerce—our rivers, railroads, and highways; our ability to construct great public works with the highest engineering skill, and our quickened national consciousness, —all call for the removal of this flood menace.

The history of the last twenty-five years has illustrated the fact that we, as a nation, have come only slowly to grasp the magnitude of this flood menace. Rather tardily, it must be admitted, have we come to see that it is something beyond the capacity of the states immediately affected, and the concern of the nation as a whole. As recently as 1917, the federal Congress appropriated forty-five million dollars, which was expected, with the addition of approximately equal expenditures by the local interests, to complete the system adequately. However, only six years thereafter, a further sum of sixty million was appropriated in the expectation of completing this big undertaking. Now we learn that the floods of 1922 and 1927 largely wiped out the expenditures to date, and today we are face to face with the fact that we have either spent too little or too much—too little if we are to do this work effectively, too much if we are doing any less.

In attempting to answer the question of why past efforts to control floods have failed, your committee has made a study of flood control efforts on the Mississippi River, going back through two centuries of levee construction to the time when New Orleans, just founded, took measures through levees to protect itself from the Mississippi. It has reviewed the studies of others in dealing with flood control measures on streams in foreign countries and compared these measures with the policy adopted on the Mississippi. It has considered the Mississippi watershed as a whole, taking into account its climatic and rainfall characteristics, analyzed these according to basins and weighed the flood conditions of the main tributary streams, and their probability of synchronizing so as to create even greater floods in the main stream. It has reviewed such river phenomena as are particularly applicable to the great delta region.

Besides the physical data and engineering work which have a bearing upon the lower Mississippi River, the committee has caused a complete study to be made of legislative, financial, and administrative measures which are important factors in this flood control problem.

As a means of getting an understanding of the physical, financial, commercial, and economic questions involved, the committee visited the flooded area. Meetings were held at which local districts presented their problems, numerous engineers—federal, state and local—were interviewed and in some instances accompanied the committee on its visits to crevasses and the chief points of interest in the devastated regions. Senators, congressmen, governors, state legislators, and men prominent in industry,—all contributed to the fund of information which the committee obtained. Much material and various plans for controlling floods were received and have been considered.

Although the direct mission of the committee was to deal with facts affecting flood control, mention must be made of other facts of national interest evident throughout the trip; the extent of human suffering, the wonderful heroism and self-sacrifice exhibited, the undaunted courage of the people in facing the future in spite of the physical and financial disasters. The flood was a great object lesson proving the innate generosity of the people. It was an object lesson of the stability of our social structure. The orderly conduct of the colored race, who were by far the greater number affected, was particularly commendable.

FLOOD CONDITIONS

The committee would be glad if it could give an adequate picture of the force and extent of the flood, but to do so is not possible. Nothing short of actual experience with the waters themselves could give this. The committee traveled for days through regions where every house bore at a height of from two to ten feet the brown line, indicating the height of the water. Where the flood was at its worst, houses were destroyed, or carried miles from their foundations. The committee saw millions of acres of rich alluvial soil covered with a mass of cockle burrs, man-high, where before there had been profitable crops. The total estimated area flooded is equal to the combined area of the states of Massachusetts, Connecticut, Rhode Island, Delaware and Maryland. The quantity of water which poured through this valley was the equivalent of ten streams the size of Niagara flowing for a period of four weeks. The statement was made in one of the addresses that at one point in Louisiana it would have been possible to cruise in a motor boat for two days out of sight of land.

What the committee saw was striking evidence of the fact that the Mississippi River drains 42 per cent of the entire area of the United States,—an area in which occurs some of the heaviest rainfall,—rainfall that over extensive areas sometimes equals two feet in less than two weeks.

The work of rehabilitation has gone on rapidly. Roads have been made passable, bridges have been replaced with temporary structures, and to some degree some kind of a crop has been produced over much of the land that was flooded. The committee saw places where there had been three, four, or five floods during the year; but notwithstanding this the people desired to remain on the soil and "come back" as agriculturists. They have confidence in the future of this region.

Determination of the practicability of flood control received the committee's fullest consideration; for on such practicability must rest the whole program of flood control.

FLOOD ELEMENTS

The committee considered the periods of flood occurrence, their extent, the factors that cause floods, probable maximum floods that must be provided for, and river characteristics. Tables, charts and tabulations dealing with these subjects are presented in the appendices.

The oft repeated statement that the effect of the levee system has been to raise the bed of the river itself has been carefully checked and found to be unsupported by the evidence for on this point, the committee is assured by those who have been making observations and studies over a long period of years that such is not the case.

NECESSITY FOR CONTROL

Types of flood control, such as levees, spillways, by-passes, outlets, and combinations of these different methods, have been considered, together with other plans for control, including reservoirs and reforestation on the headwaters of tributaries.

The committee has not attempted to develop a plan of its own, but has directed its attention to determining whether it is practicable to control floods at reasonable cost by a system of levees, spillways, outlets, etc. After listening to many of these proposals and securing the judgment of the highest engineering talent in the country, both governmental and civilian,—federal, state and local,—the committee is impressed with the unanimity of opinion that adequate control of the Mississippi River is practicable.

RESERVOIRS, ETC.

The extent to which reservoirs, reforestation, etc., on the tributaries and headwaters would assist in the control of floods in the lower Mississippi is a controverted question. The committee, after considering this, came to the conclusion that, even if such measures should prove helpful, not only would their accomplishment require many years, but they should be considered as supplemental aids contributing an additional factor of safety in the future control of floods.

In seeking the reason for failure to control floods thus far, the committee has traced the history of development of government policy, both local, state and federal, in the construction of levees along the Mississippi River. It has traced this development from private levees erected at individual expense of the plantation owners to the formation of levee districts, and finally to coöperative building by the federal government and local levee districts.

When levee construction began at New Orleans, in 1717, small earthern dikes of from four to six feet in height were all that were necessary to afford protection from floods. With the general development of the country and the action of other regions to protect themselves from floods, the vast areas which previously had afforded storage for the river were removed, and the history of the river shows a constantly increasing height of river flood crest. During this period the nation has progressed from a sparsely settled territory to one thickly populated with prosperous cities, covered with a web of railroads, public highways, and telegraph, telephone, and power lines. The day has passed when the river can be permitted to overflow its banks, disrupt the commerce of the nation, and bring vast human suffering and economic loss to the flooded area. The immediate loss to the areas affected is not a determining factor; for, while an important factor, it is only part of the general derangement to the commercial life of the nation,—directly by the interruption of commerce, and indirectly by the economic loss which falls on every citizen.

Unfortunately this demand for flood control, calling for higher levees and for other methods of flood control in the interest, not alone of the affected areas, but of the nation as a whole, has outstripped the ability of the flooded areas to pay. The history of the levee districts shows that in some instances districts have taxed themselves beyond their ability to pay. While some regions are better able to pay than others, a proper system of flood control is exactly like a chain, no stronger than its weakest link. Of the twenty-nine levee districts stretching from Cairo to the Gulf, many have reached their full legal tax limit. Many not only cannot pay further sums for the greatly increased expense required, but cannot pay their existing obligations save at great sacrifice.

Thus far the total expenditures since 1882 of all agencies in the construction of levees amount to $225,000,000; whereas the federal government has expended directly for similar work $65,000,000. The local agencies have expended nearly three dollars to every dollar spent by the federal government.

The investigations of the committee revealed the following reasons why the federal government should bear the entire cost of construction. The problem of flood control is national, particularly because it involves directly or indirectly the flow of commerce, north and south and east and west, in the very heart of the nation. The federal government is authorized under the provisions of the federal constitution to deal adequately with a problem so vital to commerce. Moreover, national defense requires the federal government to see that the nation may not be subject to the derangement of transportation and of the general destructive effects of floods upon the nation in time of war. One speaker asked the question, "What would have been the effect upon the efforts of the United States if the flood had come at the height of our activities in the World War?" and he asked further, "What would be the effect upon the nation if such a flood should happen when we were in a desperate struggle with foreign invaders?" During the recent flood, operation was suspended from 10 to 120 days on 3000 miles of railroad.

The principle that the federal government carries a responsibility for control of floods of the lower Mississippi was recognized in the Mississippi River Commission Act of 1879, which set up that commission and provided funds for work on the Mississippi River. The condition of expecting the local districts to carry the major part of flood control work persisted, however, and the amounts spent by the federal government between 1879 and 1917 for flood control are as follows: federal government, approximately $23,000,000; local levee districts approximately $143,000,000. In 1917, however, the federal government took a long step toward accepting full responsibility for controlling floods and assumed two-thirds of the construction costs of control works, the other one-third of construction costs and rights of way and maintenance being left to local districts. Under the Flood Control Act of 1917, and the further legislation of 1923, the federal government has appropriated in the last ten years over $86,000,000 for flood control works whereas local levee boards have spent about $17,000,000.

SOLE FEDERAL RESPONSIBILITY

The history of the relationship between the federal government and the local districts ndicates clearly a growing appreciation of the need of sole federal responsibility. Levee listricts and bordering states should not be called on to pay all or part of works that are learly a national responsibility. Such a principle is seldom applied to harbor works, ocks, or dams, or in many instances to highways, which are constructed under the commerce clause of the constitution. It is just as fallacious to attempt to protect the heart of ur country from floods by placing the duties both financial and protective upon the bordering districts as it would be to place the protection of our national boundary upon the oundary and coast states, or to call upon the ports of our nation to stand the expense of heir navigation improvements.

The committee found that the present arrangement, which calls for local contributions nd maintenance, results in a divided responsibility, and is destructive of success in planing, constructing, and maintaining the works necessary for flood control. The federal overnment in assuming its responsibility for the development of adequate flood control works should not have to deal with the local influences which grow out of this contriution system. Finally, in the words of one member of the committee, "It is a condition nd not a theory" which confronts the nation in dealing with this flood control problem. Many of the levee districts are unable to do their part in maintaining the system as exists today, a system which is obviously inadequate. Clearly they cannot furnish reater contributions to the enlarged program of construction which now faces the nation. he entire project cannot be permitted to lag because of the inability of any of the units to ntribute.

The committee has had before it proposals that the federal government should enter to agreements with the affected districts looking to contributions in later years. Precedent is against this principle as applied to works of a national character, and we believe it to be unsound.

In view of the universal demand for unified control and undivided responsibility in meeting this national problem for flood control on the Mississippi River, the local and state governments should not be called upon for further contributions, which, in view of the enlarged expenditures required, would be a small proportion of the whole, and would tend to interfere with the proper discharge of the federal government of its obligations to deal effectively with this problem in a national way.

RECOMMENDATIONS

The federal government should hereafter pay the entire cost of constructing and maintaining works necessary to control floods of the lower Mississippi River. (For the purpose of this report, lower Mississippi means from Cairo to the Gulf.)

The federal government should assume the sole responsibility for locating, constructing and maintaining such works.

As a result of its studies the committee is forced to conclude that the reason why the Mississippi River is still uncontrolled is a weak financial plan and inadequate and divided administration, and not inability of the nation's engineers to develop adequate plans. Unfortunately thus far the problem put up to the engineers has not been, "What levee will you build to safeguard the country behind it, and what will it cost?" The engineer has been given a certain sum of money to be expended in a given district and told to make it go as far as possible.

APPROPRIATIONS

That any plan of flood protection which may be adopted may be carried forward in the most economic and efficient manner, the rate at which appropriations may be expected must be definite. The first years of carrying into effect the project finally adopted will naturally call for sums less than in the later years when the organization has been fully perfected. Statements unfortunately have been made that enormous sums of money will be required immediately to deal with this project. Undoubtedly in the aggregate large sums will be required, but expenditures must necessarily be spread over a period of years, and certainly the amounts required for construction during the next year or two will in no way cast a burden upon the Treasury or interfere with the government's fiscal policies.

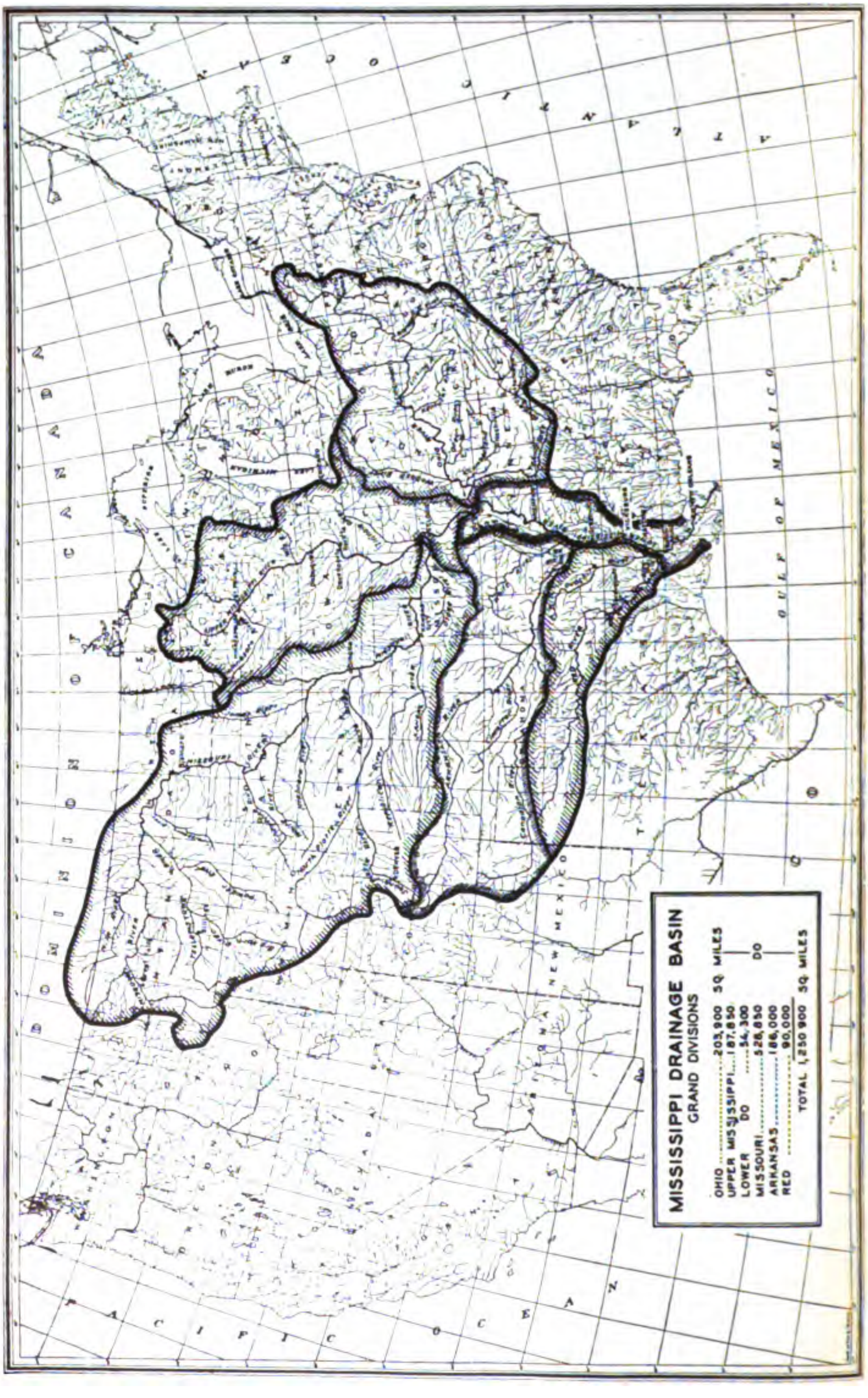
Inadequate appropriations in the past have materially delayed the carrying out of a systematic plan of protection. They are sufficient reason for insisting upon a proper financial scheme at this time. What the final cost of the project now being designed by the Mississippi River Commission and the Army engineers will be, can be only approximated at this time. The cost of this plan, or some modification, is not an issue. Competent authorities assure us, and we confidently believe, that the expense, though large, is one the nation can well afford to pay. Possible variations in the total figures are unimportant. The job must be done. It must be done as rapidly as the organizations for doing it and the detailed plans for the work can be perfected, after the project itself has once received national approval.

The necessary money must be available as needed. Conditions in the past may have justified the course which the federal government has pursued. On this point no comment need be made. We must accept the past as it is and profit by the experience gained. To permit this periodical destruction to continue, would be not only an indictment of our patriotism and wisdom, but an unescapable indication that we are unwilling to use our present vast national wealth and our administrative and engineering ability to remove this menace from the heart of our country. We, therefore, recommend that, *there should be an adequate appropriation to insure efficient, continuous and economic work, the funds to be made available as needed.*

In attacking this great national problem in which the federal government is to assume sole responsibility for its solution, and is to pay the entire cost of the project, the project itself must be definitely conceived and set apart from all other domestic problems. It must be singled out and the solution considered and financed free from any relationship with other national or local problems. This is necessary because of the nation's interest in a complete and permanent solution. Such a solution can have nothing less than the support of the whole country. It must have particularly the support and judgment of all business interests. These cannot be divided, nor can they be considered in any way as related to similar developments elsewhere. This nation built the Panama Canal under just such circumstances, and in some respects this project is a more important one than building the Panama Canal. That project was a definite and entirely separate undertaking by the federal government. In such manner should the government attack the problem of flood control in the Mississippi River. It must not be entangled with any local conditions or limitations, financial, physical, or political. Neither should it be tied in with internal developments elsewhere within the country. The control of the Mississippi River floods is now more than ever before our greatest domestic problem. Legislation should deal with it singly, and free from other projects.

The committee had presented to it suggestions for extending flood control to tributaries of the lower Mississippi River and it has considered plans on a much larger basis involving the entire Mississippi River watershed; but it has always been forced to return to the important problem facing the main-trunk system of the lower Mississippi River. So long as the system of flood prevention in the lower region remains incomplete, this region requires first attention. The government is already prosecuting a study of the problems of tributary streams under an appropriation by Congress made for that purpose. The committee therefore makes no recommendation on this subject, pending that investigation.

We have recommended that sole responsibility for constructing the works to control floods be placed upon the federal government and the payment of the entire cost by the federal government in order to fortify this responsibility. It is equally important that the plan of administration should be centralized. As stated before, the project is likely to be more extensive than the Panama Canal and we may well take a leaf from the nation's experience with that great project. There should be a carefully formed organization adapted to carry on and complete a project of such proportions, vested with ample power for the necessary research by way of preparation for the adoption of its plans, and for carrying out the work, and with full discretion in all matters of engineering, operation and maintenance. We, therefore, recommend that, *flood control of the Mississippi River is a work of such magnitude and urgency that it should be dealt with in legislation and administration upon its own merits, separate and distinct from any other undertaking.*


MISSISSIPPI DRAINAGE BASIN
GRAND DIVISIONS
OHIO 203,900 SQ MILES
UPPER MISSISSIPPI 187,850
LOWER DO 54,300
MISSOURI 528,850 DO
ARKANSAS 186,000
RED 90,000
TOTAL 1,250 900 SQ MILES
DOMINION OF CANADA
ATLANTIC OCEAN
GULF OF MEXICO
PACIFIC OCEAN
NEW MEXICO
ARIZONA

The Plan[1] for Flood Control of the Mississippi River in Its Alluvial Valley

Presented to the Secretary of War and by Him to Congress

By Major General Edgar Jadwin
Chief of Engineers

I HAVE the honor to submit the following project for the flood control of the Mississippi River in its alluvial valley.

The plan is a comprehensive one, providing for the maximum flood predicted as possible, and for future expansion to meet changing conditions. It includes a spillway above New Orleans, diversion floodways in the Atchafalaya and Tensas Basins, a river bank floodway from Cairo, Illinois, to New Madrid, Missouri, together with strengthening and a moderate raising of existing levees. It is designed to prevent any material increase in flood stages. Channel stabilization and navigation improvement are included. Exclusive of rights of way, incidental drainage works, and damages, if any, recommended to be borne by local authorities, the estimated cost of flood control works is $185,400,000, and of channel stabilization and mapping $111,000,000; a total of $296,400,000. The distribution of cost must be determined by law. The suggestion is made that a distribution by which the cost of flood control works in general is borne 80 per cent by the Federal Government and 20 per cent by the Valley States, and the entire cost of channel stabilization is borne by the United States, would accord with the fiscal policy of the President and the precedents established by Congress. The reorganization of the Mississippi River Commission, Federal control over structures within natural floodways, and the comprehensive mapping of the alluvial valley are also recommended. Flood control of tributaries will be reported upon after the completion of surveys already authorized by Congress.

The control of Mississippi floods by reservoirs is shown to be too costly to warrant their construction. Their development for local benefits is discussed. Other suggested schemes, including levees of sufficient height to contain the maximum possible flood, are discussed, but found inadvisable.

Essential Features

The recommended plan fundamentally differs from the present project in that it limits the amount of flood water carried in the main river to its safe capacity and sends the surplus water through lateral floodways. Its essential features and their functions are:

> Floodways from Cairo to New Madrid, from the Arkansas River through the Tensas Basin in the Red River, and from the Red through the Atchafalaya Basin to the Gulf of Mexico. These will relieve the main channel of the water it cannot carry and lower the floods to stages at which the levees can carry them.
>
> A controlled spillway to hold the levels down to safe stages at and near New Orleans.

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[1] This is a copy of that part of this report in which the plan is presented.—*The Editor.*

Local setting back of the levees in the main river at bottle necks to increase its carrying capacity and reduce its flood heights.

Greater protection against crevasses by strengthening the levee by reducing flood heights through the increased widths of channel afforded by floodways, spillways and setbacks, and by moderately raising the levees where needed to meet predicted flood stages.

The progressive revetment of caving banks to protect the foundation of the levees and to stabilize the river both for flood control and navigation.

Improved navigation channels for river traffic, not less than 300 feet wide and 9 feet deep, to be obtained by dredging and draining works where necessary between Cairo and New Orleans.

The estimated construction cost of the complete plan is $296,400,000, and it can be advantageously executed in approximately ten years.

The project recommended gives the maximum of results for the minimum of cost. It recognizes the interests and protects the rights of those who will be chiefly benefited and of the taxpayers who furnish the funds. Complete flood control embodying the cheapest practicable reservoir system would be much more expensive.

The plan heretofore pursued has been the construction of levees high enough and strong enough to confine all of the flood waters within the river channels. The levees that have been constructed are not sufficiently high for such floods as are now predicted. The cost of raising and strengthening them sufficiently to carry extreme floods would greatly exceed the cost of the plan proposed. Furthermore, the extent of the disaster which follows a crevasse increases greatly as the flood is forced to higher stages by confinement wholly within the levee system. The loss of life and property in the recent great flood in the alluvial valley followed the breaking of the levees which reclaimed the land for the use of man. This reclamation had been pushed so far that insufficient room was left in the river for the passage of the unprecedented volume of flood water. The levees must be strengthened, but a halt must be called on further material increase in their heights and the consequent threat to the inhabitants of the areas they are built to protect.

Man must not try to restrict the Mississippi River too much in extreme floods. The river will break any plan which does this. It must have the room it needs, and to accord with its nature must have the extra room laterally. In its original state the river had only one low water channel until it reached the flat land near the Gulf, but in flood it overflowed an area 50 miles wide, which is really its natural flood bed. The water which cannot be carried in the main channel with the levee at reasonable height must be diverted and carried laterally. Some additional capacity can be obtained in the main river by local setbacks of the levees. As a general setback is not practicable the remainder must be supplied by floodways paralleling the general course of the river.

The plan recommended provides the requisite space for the passage of floods, and levees of adequate strength to withstand them, so that should a flood recur of the magnitude of the flood just experienced, the maximum of record, it would be passed out to the Gulf without danger to life in the alluvial valley, and without damage to property except in the floodways allotted for its passage. Controlling side levees limit the area of the floodways, and protect land not in the floodways where such protection justifies its cost.

Should Divine Providence ever send a flood of the maximum predicted by meteorological and flood experts as a remote probability, but not beyond the bounds of ultimate possibility, the floodways provided in the plan are still normally adequate for its passage without having its predicted heights exceed those of the strengthened levees. The plan is designed to be both simple and comprehensive, flexible and adequate to prevent a calamity such as that of 1927 from happening again as the result of any flood past or predicted. It is capable of modification or expansion, if desirable, to further accommodate an increasing population and its property.

FLOOD CONTROL OF TRIBUTARIES

Plans for the flood control of the tributaries will be developed as funds become available in accordance with an act passed at the last session of Congress. It is impracticable to present such plans at this time, because of lack of data and time. Congress recognized the need for further data when at its last session it enacted a law in the River and Harbor Act, approved January 21, 1927, authorizing and directing surveys by the Corps of Engineers of a large number of rivers, including the tributaries of the Mississippi, to determine the best use of their water resources. Flood control, power, irrigation, drainage, navigation and water supply must all be considered. This act was designed to promote the harmonious and coördinate development of all our water resources. Work on these surveys will require several years and will be expedited as funds are made available in future appropriation bills. Much work which has been done in arriving at the present alluvial valley project, particularly that done in the study of reservoirs, will be of value when the tributary studies are undertaken. Many reservoirs on the tributaries which would be of little help to the Mississippi will be of great value in the control of floods on the tributaries as well as for other uses.

For the above reasons, only the lower courses of such tributaries as are directly connected with the flood control of the Mississippi in the alluvial valley are included in the plan herein. The other parts of the tributaries will be reported on as soon as practicable as contemplated by the Act of Congress referred to above.

DESCRIPTION OF PLAN FOR FLOOD CONTROL OF ALLUVIAL VALLEY

The details of the plan by which the surplus water will be carried with safety vary in different parts of the river. The alluvial valley of the river may be considered in three principal sections; the northern, comprising the St. Francis Basin on the west side of the river; the middle, including the Yazoo Basin on the east, and the Tensas Basin on the west, running on the east from near Memphis to Vicksburg and on the west from the Arkansas River to the Red River; and the southern, or Louisiana Section, from the Red River to the Gulf of Mexico.

The portion of the alluvial valley from Cape Girardeau, the northern limit of the alluvial valley, to Cairo, can be protected by a slight increase in the size of the levees. The serious problem begins at Cairo at the confluence of the Ohio and the Mississippi. From here to New Madrid the main levee on the west bank chokes the river unduly and should be set back sufficiently to lower the head of water at Cairo by 6 feet in an extreme flood. The existing river bank levee will be retained, but lowered 5 feet. The floodway between the new and the old levees will be capable of cultivation at all times excepting in floods greater than that of 1922.

An estimate is included for removing part of the dike on the Tiptonville Ridge to reduce the backwater area at the mouth of St. Johns Bayou to the minimum practicable.

From New Madrid south to the mouth of the Arkansas, the levees will be raised moderately. Local setbacks will be made below Helena and at other bottlenecks where necessary to restore greater cross sections in the main river. These modified works are designed to carry the highest predicted flood, except that it may be found expedient not to raise the levees opposite the backwater areas of the St. Francis and White Rivers. In this event, if a possible superflood should come, it may cause a crevasse in the levees at these points, increasing somewhat the height and acreage of backwater area, but doing comparatively little harm.

From the mouth of the Arkansas to the Old River, at the mouth of the Red, extreme floods cannot be carried between levees of the Mississippi without dangerous increase in their heights. A floodway for excess floods is provided down the Boeuf River, on the west side of the river. Excess water cannot be carried through the section on the east side, since it would be forced back into the main river by the high lands on the east bank below Vicksburg and have to be carried thence for 160 miles between the main river levees to the mouth of the Red River. The entrance to the floodway is closed by a safety plug section of the levee, at present grade, which is located at Cypress Creek, near the mouth of the Arkansas. To ensure their safety until this section opens, the levees of the Mississippi, from the Arkansas to the Red, will be raised about 3 feet. To prevent flood waters from entering the Tensas Basin, except into the floodway during high floods, the levees on the south side of the Arkansas will be strengthened and raised about 3 feet as far upstream as necessary.

The section at the head of the floodway will protect the land within the floodway levees against any flood up to one of the magnitude of the 1922 flood. A flood of a magnitude somewhere between that of 1922 and of 1927 will break it, turning the excess water down the floodway, which will carry it safely to the backwater area at the mouth of the Red River.

Below the Red River, setbacks of the levees will be made at critical places in the main river, to insure the better discharge of flood waters, but the carrying capacity of the main river cannot be increased materially without unwarranted hazard to life and property in the state of Louisiana. At the city of New Orleans, an increase in levee height is considered unsafe, aside from the great cost of raising the levees and the wharves built upon them. To afford proper protection to New Orleans, with its population of nearly half a million and property value of over a billion dollars, a special floodway upstream from the city is essential. The most practicable location is on the east side of the river, discharging into Lake Pontchartrain. A controlled spillway at Bonnet Carré will limit the discharge through this floodway to that necessary for the protection of the city.

At high floods it is also necessary to divert down the Atchafalaya Basin the flood waters in excess of the discharge capacity between the levees of the Mississippi. This is accomplished by strengthening and raising the levees on the main river 3 feet for the necessary distance to assure their safety until levees at the head of the Atchafalaya

Basin open. The levees on the south bank of the Red River will be strengthened and raised sufficiently to keep flood waters from entering the Atchafalaya Basin except in the floodway, through the relief or fuse plug levees at the head of the floodway. Back levees are to be constructed on both sides of the Atchafalaya Basin for the major part of its length, to enclose the Atchafalaya floodway. Funds are included in the estimate for the extension of these levees to the south, to limit the overflow in the lower part of the Basin.

Existing levees on the Atchafalaya River will be strengthened and their grade adjusted so that the productive capacity of such parts of the floodway as are not already swamp land will be retained during any flood of record of a less magnitude than that of 1927.

The plan includes an extension of revetment of the banks of the river, to reduce the danger of attacks on the foundations of levees and their destruction by caving banks, thereby to further reduce the possibility of crevasses and to stabilize the position of the river in order that contraction or regulation works may be provided, to assist in securing and holding the low water channels needed for carrying the commerce of the valley in low water as well as in high.

The area in the alluvial valley that would be flooded by Mississippi River water if there were no protecting works is approximately 30,000 square miles. Under the plan recommended, barring accident, approximately 20,550 square miles will be protected annually. The remaining 9450 square miles, of which approximately 3340 square miles is cleared land, will be protected on an average of from 2 years in 3 to 14 years in 15, depending upon its location. The remaining 6110 square miles are swamp and timber land which is not injured by flood.

The estimated cost of $296,400,000 for the construction of flood control and navigation work does not include the costs of rights of way nor possible damage to structures which have invaded the natural flood bed of the river. It is expected that these, if any of them are legal and proper, will be borne by the states or other local interests who will in general be greatly benefited by the execution of the plan.

ECONOMIC NECESSITY AND LOCAL COÖPERATION

As directed by the law relating to reports by the Department, I submit a statement as to the general and local benefits of the plan and the local coöperation that should be required on account of local benefits. The question must be viewed from the standpoint not only of those in the valley needing flood protection, but also of the taxpayers in other parts of the country, including the regions from which the flood waters come, who suffer indirectly from flood disasters, and on whom the bulk of the burden of Federal expenditure must fall.

Several estimates of different well-protected parts of the delta valley result in an average price per acre of $224 when towns and all property, such as houses, roads, railroads, land, etc., are included. The total area of the valley originally subject to overflow is 29,790 square miles, or 19,065,600 acres, 12,000,000 acres of which is usable. This 12,000,000 acres at $224 per acre is worth about $2,688,000,000. Adding the probable value of New Orleans would bring this sum up to about $3,500,000,000. Movable property added would make it something like $5,000,000,000.

The value and population behind the levees are increasing all the time. It has been estimated that damages from the 1927 flood were over $200,000,000.

The plan for river control contemplates spending about $3,000,000,000, or about one-sixteenth of the value estimated above. On the basis of 12,000,000 acres of usable land, this is an average expenditure of about $25 per acre, but it must be remembered that this includes protection to cities, towns, etc.

The cost of the project is unquestionably justified. It will prevent a repetition of the widespread disaster, human suffering, dislocation of the economic life of the valley, interruption of interstate commerce, and the effect on the general welfare of the nation, that attended the recent flood. The expenditure would be justified even though such a flood occurs but once in 150 years. It will prevent the less extensive flood disasters that are likely to occur at much more frequent intervals. The protection afforded to the cities back of the levees in the valley against a flood even greatly exceeding that just past is especially justifiable from a humanitarian standpoint, since an unexpected break in the levees at these places would probably result in serious loss of life and might be an unparallelled catastrophe.

The estimated cost of $296,400,000 for the construction of flood control and navigation works does not include the costs of rights of way for flood control works, the cost of any drainage works required therewith nor the cost of any flowage rights that may be required, nor damages, if any, resulting from the execution of the plan. No questions of rights of way or damages arise in connection with the navigation works. Local interests should in the future as in the past provide all rights of way for flood control structures. They best can obtain the land at a fair value, and vexing questions as to Federal ownership, administration or police of the narrow strips of land will be eliminated. Their land is enhanced in value by the works. Tax collections show that the land in the Upper Yazoo Basin has ten times the value that it had before it was leveed. The United States ought not to buy a part of the land to enhance the value of the rest.

Such drainage works as will be required in connection with new interior levee construction are of direct benefit to the lands affected and their cost should be borne locally.

It is a fundamental principle that no damages lie against either Federal or State Government, or local agencies, on account of an accidental crevasse in the levees. The plan has been drawn to reduce to a minimum the damage to lands and structures resulting from the flow at high floods through the floodways. All property affected lies in the natural high-water bed of the river. Much of this land was transferred to the states by the Swamp Act approved September 28, 1850. The purpose of this Act was to enable the states to construct the necessary levees and drains to reclaim the swamp and overflowed lands therein. The principle involved was not new, as the early French grants in the lower valley contained a proviso requiring the grantee to construct and maintain a levee line along the river front of his property. In the state of Louisiana, this old servitude has been transferred by the state to the levee district in which the land is located. Whether or not the servitude of flooding was transferred to private owners when the land was sold, the servitude existed when the land was granted to the states without cost. It should not now be paid for by the Federal Government. Moreover, the lands, with some exceptions, will have the same protection as is afforded by the present levee system, a protection provided partly at the expense of the Federal Government.

The exceptions are the lands in the Bonnet Carré floodway and in the setback floodway from Bird's Point to New Madrid. The acquisition of flowage rights by the state or local interests may be necessary in these cases. In any case, the lands should remain in private ownership in order that their productive capacity may be fully availed of. The United States does not in general own the bed of navigable streams; much less need it own land flooded only at long intervals. Damages, if any, which may be found legal and proper as a consequence of the plan should be met by the states, since these will be directly benefited by the works.

The project should be authorized subject to the condition that, except when specially authorized by the Secretary of War, upon the recommendation of the Chief of Engineers, no Federal funds shall be expended upon the part of the project within any state until that state has accepted by appropriate legislation these conditions and responsibilities. The saving exception is suggested to cover the case where the procedure requisite to the enactment of the legislation would unduly delay the initiation of work of far-reaching benefit, particularly if such work is essential to the protection of another state which has fulfilled these conditions.

The present Flood Central Act provides that local interests shall pay one-third the cost of levee construction. The following table shows the proportions of the cost of levees actually borne in the past by the Federal Government and local authorities:

AMOUNTS EXPENDED BY THE UNITED STATES GOVERNMENT IN THE CONSTRUCTION OF LEVEES AND THE AMOUNTS EXPENDED BY STATES, LEVEE DISTRICTS, AND COMMUNITIES INTERESTED, FROM 1882 TO DECEMBER 31, 1926, COVERING COST OF YARDAGE PLACED, RIGHTS OF WAY, INTEREST, ENGINEERING EXPENSES, REPAIR WORK, HIGH-WATER EXPENSES, CREVASSE CLOSING, ETC.

M. R. C. Districts	Expended by United States from Government Funds	Expended by United States from Contributed Funds	Expended by State and Local Organizations	Total
Northern	$3,127,533.49	$1,083,857.69	$9,916,110.91	$14,127,502.09
First and Second	19,796,161.78	4,348,420.82	42,766,497.05	66,911,079.65
Third	27,614,208.84	5,852,103.37	34,782,460.96	68,248,773.17
Fourth	20,552,089.47	3,773,898.32	64,488,106.33	88,814,094.12
Total	$71,089,993.58 30%	$15,058,280.20 7%	$151,953,175.25 63%	$238,101,449.03

In addition to meeting the costs shown in the table, the inhabitants of the valley have been subject to recurring flood damage. The direct damages suffered from the 1927 flood are estimated by the Mississippi Flood Control Association to have been $236,334,414.06.

The table clearly shows that the people of the valley have borne much the greater part of the cost of flood protection, although the United States has given substantial aid. The local participation has furthered the keen interest of each locality in the proper execution of the work. It has afforded a check on pressure for the execution of works not economically justified.

The division of cost has led to some division of control. The enlargement of levees affecting large areas has been delayed, in some cases, by the failure of a levee district to furnish its share of the cost. It is doubtful whether these disadvantages have counterbalanced the advantage of a local proprietary interest in the works.

The comprehensive plan now presented does not include the protection of areas whose reclamation is not economically justified, but contemplates that such areas be left open for temporary storage and the discharge of floods. If no local contribution is required, the law and the administration of this project must be relied on to prevent the construction of works not economically justified. If a contribution, small in comparison with the cost of work already done and to be done, will assist materially in retaining the proprietary interest and watchfulness of local authorities, it would seem to be justified.

In view of the national aspect of the flood control problem from the standpoint both of the cause and of the effects of the floods, and in view of the large sums spent in the past by the people of the valley for flood protection, the sacrifices they have made in meeting their allotments, the great losses suffered in the past flood, and the larger expenditures now required, it is believed that the United States should bear a larger proportion of the cost of construction than in the past, and that of the states or local interests be as small as consistent with the results desired. While the proportion must be determined in the wisdom of the President and Congress, a division by which the United States bear 80 per cent and local interests 20 per cent of the cost of levee construction and control works in general; and by which the United States bear 50 per cent and local interests 50 per cent of the cost of the special ring levees proposed at Morgan City, Melville, Simmesport and Arkansas City, would be in general accord with the existing policy of the President and the precedents established by Congress.

The expenditure for flood control structures proper, required in the comprehensive plan herein recommended, exclusive of navigation works, revetments, etc., is $185,400,000.

On the basis suggested, the total construction costs would be divided as follows:

BY THE UNITED STATES

80% of general levee and control works............	$147,360,000
50% of special protection work	600,000
100% of works for channel stabilization and mapping navigation...........	111,000,000
Total...................	$258,960,000

BY LOCAL INTERESTS

20% of general levee and control works............	$36,840,000
50% of special protection works..	600,000
Total....................	$37,440,000

The local interests are also expected, under the project, to furnish rights of way, and protect the United States against charges for flowage easements and damages.

While $37,440,000 is small in comparison with the amount to be spent by the United States and with the amounts already spent by the people of the valley, it must be remembered that those people still owe considerable sums on their bonds on which the money spent was raised. Some of the levee districts are also near the limit of their bonding power under present state law and also near the limit of their credit. However, it is not equally clear that this expenditure, spread over a ten-year period among four or more states, would constitute an unreasonable burden, on the states themselves, in view of the increased taxable values which will result from the improvement.

SUMMARY OF PROJECT

I recommend the adoption and authorization of a comprehensive project for the flood control of the Mississippi River in its alluvial valley and its improvement from the Head of the Passes to the Ohio River as set forth in this document, to be prosecuted under the direction of the Secretary of War and the supervision of the Chief of Engineers; the project to include the floodways, spillways, levees, channel stabilization, mapping, etc., hereinbefore recommended, with such modifications thereof as in the discretion of the Secretary of War and Chief of Engineers may be advisable, and the maintenance of a navigation channel from Cairo to New Orleans not less than 300 feet in width and 9 feet in depth, all at an estimated initial cost of $296,400,000 with $6,000,000 annually for maintenance after completion of project, with such distribution of costs as may be specified by law after considering the statements on economic necessity and local cöoperation in paragraphs 25 to 42 inclusive. Its adoption should be made subject to the provision that, except when authorized by the Secretary of War upon the recommendation of the Chief of Engineers, no funds appropriated by Congress for the execution of the project shall be expended on works within a state until that state by appropriate legislation

(a) Has undertaken to provide without cost to the United States and when required the rights of way for all levee structures, and such drainage works as may be made necessary by new levee construction.

(b) Has consented to the maintenance of the levee at the head of floodways within the state at the grades and cross sections necessary in the opinion of the Chief of Engineers for the security of the levee system and the lands protected thereby.

(c) Has agreed to hold and save the United States free from all damage claims resulting from the construction of the project; and to maintain all flood control works after their completion, except controlling and regulating spillway structures.

I recommend that the Secretary of War be authorized to continue in his discretion, and under the supervision of the Chief of Engineers, the prosecution of such works for the flood control of the Mississippi River as have heretofore been authorized and are not included in the project herein recommended; to expend, in an emergency, funds appropriated for the execution of the project on the maintenance of any levee, when it is demonstrated to his satisfaction that the levee cannot be adequately maintained by local interests; and to secure the assistance, whenever practicable, of the United States Geological Survey, the Coast and Geodetic Survey or other mapping agencies of the Government in the preparation of maps required in furtherance of the project, and to allot funds therefor to them from funds appropriated for flood control work.

I further recommend that legislation be anacted:

(a) Prohibiting any obstruction not affirmatively authorized by Congress to the flood discharge capacity of the alluvial valley of the Mississippi River below Cape Girardeau, and providing that it shall not be lawful to build or commence the building of any levee or other structure in said alluvial valley, or in any floodway provided therein unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War.

(b) Providing that the penalties and procedure applicable to violations of the laws for the protection and preservation of the navigable waters of the United States, enacted in Sections 12 and 17 of the River and Harbor Act of March 3, 1899, shall apply to violations of the above provision of law.

(c) Providing that existing laws relating to the acquisition of lands, easements on rights of way needed for a work of river and harbor improvement shall be applicable to the acquisition of lands, easements or rights of way for flood control works.

(d) Amending Sections 3 and 4 of the Act of June 28, 1879, constituting the Mississippi River Commission; to provide that it shall be the duty of said Commission to advise on all questions relating to the improvement of navigation on the Missisippi River and the prevention of destructive floods which may be referred to the Commission by the President of the Commission or higher authority, and to provide that the President of the Mississippi River Commission shall have the qualifications now prescribed by law for the Assistant Chief of Engineers, and shall receive the rank, pay and allowances of a Brigadier General of Engineers while actually assigned to such duty by competent orders.

What Forests Can Do for the Mississippi River

By E. A. Sherman
Associate Forester, U. S. Forest Service

IN 1879 the Government of the United States recognized that the control of the periodic floods of the Mississippi River was a national problem. To meet this problem Congress created the Mississippi River Commission, consisting of seven members, three of whom are selected from the Corps of Engineers, United States Army, one from the Coast and Geodetic Survey, and three from civil life. This Commission operates under the direction of the Secretary of War and the Chief of Engineers. Its integrity and devotion to duty have never been questioned.

This Commission after a careful study developed a plan for controlling the floods by means of a system of levees and, with the approval of Congress, work thereon started in 1882. Up to June 30, 1926, there had been expended in the furtherance of this plan a total of $174,469,931.06 on the Mississippi River, $81,686,285.56, including $16,689,146.66 contributed by local interests, being for flood control.

In his report for the year ending June 30, 1926, the Chief of Engineers, United States Army (page 1793), said:

> *Effect of Improvement.*—It may be stated in a general way, the improvement is providing a safe and adequate channel for navigation and is now in condition to prevent the destructive effect of floods.

Then came the flood of 1927, the greatest physical disaster in American history. Of the 30,000 square miles threatened with inundation, the levees successfully protected 12,000 square miles having a larger percentage of cultivated land than the 18,000 square miles flooded. Nevertheless the resulting loss of property was great and fell upon a people already heavily debt-burdened for the construction of costly flood defense works. Loss of human life was providentially small, but the suffering, misery, and despair was such as is only known by a people who have to flee their homes before the advancing hosts of an invading army. In this case the invading army was water instead of armed men. The element of personal conflict was absent but in its stead was an impersonal relentless element that covered all things, penetrated everywhere, and when it withdrew left behind only death, filth, ruin and decay.

These facts are recited, not with the thought of charging delinquency to the Commission. Omnipotence cannot be expected of any human agency. Rather are they recalled as proof that the problem is one of controlling great natural forces and that no system of protection that man erects can have factors of safety so great that assistance from other sources should be ignored. Doubtless the Commission itself would be the first to subscribe to such a conclusion. Probably there is nowhere in the country today any considerable sentiment for "levees only," but even the writer of this article acknowledges a conviction favoring "levees first."

In the past there has probably been a tendency to overstate the case both for and against forests as a factor in flood control. Let it, therefore, be understood at the outset that the writer does not advocate forests as a substitute for levees. Levees are necessary now, always have been necessary, and certainly will be necessary for generations to come. They should be constructed high enough and strong enough to control the greatest flood within the range of reasonable probability. This country is rich enough and resourceful enough to construct a system of levees of that kind, and the writer would not advocate diverting from such a project a single dollar necessary to its successful completion.

The problem of providing immediate protection to the region threatened by flood waters can only be solved by the construction engineer whose field of direct responsibility is the protection of a limited area of about 30,000 square miles, formerly used by the Mississippi River periodically as part of a great flood channel, but now taken over by man for agricultural and other purposes. At the same time there is a great problem of land use which also has a direct bearing on the regimen of the Mississippi. It involves the entire area of about 1,225,000 square miles which contributes its surplus waters to that stream. The use which is made of any part of that vast area directly affects runoff and runoff makes floods.

One of the most common forms of use to which land is put is the growing of forests. Generally speaking, the lands so used are those having the most direct bearing on floods. They are lands too rough and steep for cultivation and the high mountain lands which receive a heavier precipitation than the plains lands. Forests of swamp or bottom type and on level sandy soils which absorb the heaviest rainfall without washing are exceptions to the general rule.

Originally about 60 per cent of the Mississippi basin was treeless and 40 per cent forest. In De Soto's time the river was subject to floods. The Missouri brought down its great loads of silt from the "Badlands" and the Arkansas brought its burden of soil from "The Breaks" at the edge of the "Staked Plains," and each spring the flood waters deposited a layer of silt over the 30,000 square miles which we now wish to permanently reclaim.

Since De Soto's day the proportion of forest land in the valley has been cut to 20 per cent, or about 250,000 square miles. It is idle to expect that the proper use of this relatively small proportion of the entire watershed could prevent floods. Upon the other hand it is equally absurd to say that the use of so great an area has no bearing on resulting floods and runoff. Avoiding extremes in either case, one may expect provisions for the efficient protection and management of the forests now existing on the watershed and the replanting of lands which are now washing badly and should never have been cleared, will be included in future plans for Mississippi flood control, and that such use of land will add materially to the security and permanent usefulness of the supplementary levees and other necessary engineering structures.

For a clear understanding of the influence of forests on streamflow regulation one must take into consideration certain laws of physics governing the power of running water. First, the erosive or abrading power of a stream varies as the square of its velocity. For example, if the velocity of the stream is increased ten times its erosive power is increased one hundred times. Second, the transporting power of water varies as the sixth power of its velocity. For example, if the velocity of a stream is increased ten times, its transporting power is increased one million times. A current two miles an hour will move along its channel fragments of stone the size of a hen's egg, weighing about three ounces, while a torrent of twenty miles an hour will carry boulders weighing one hundred tons.

It is a self-evident fact that water falling on steep lands tends to rapid runoff. The laws just cited show that erosion is tremendously increased by rapidity of runoff. It follows that for any given type of soil the steepest lands are most subject to erosion. Therefore it is upon steep rough lands that forests as an erosion-preventive factor are most important.

Coincident with retarding erosion and runoff, forests also retain a considerable volume of moisture and increase the amount taken up by the soil. Not only is the earth protected from beating rainfall but the precipitation is broken up by the leaf canopy, and must either settle in the form of mist or reassemble on twigs and branches and slowly trickle to the ground. Also, if the forest has been protected from fire and excessive tramping of stock, the trickling moisture encounters a layer of humus composed of dead leaves and other vegetation which readily absorbs water amounting to several hundred times its weight.

A layer of humus four inches deep will easily retain and transmit to the soil one inch of rainfall. This statement is conservative. The immediate water storage capacity of such a forest may therefore be calculated as equivalent to 3630 cubic feet. The effect of increasing water storage on a single acre would hardly be noticeable on the smallest stream. The effect of even a million acres would scarcely be noticed in the volume of a great Mississippi flood. However, it is just as true of the Mississippi flood as it is of the smallest rivulet that its burden of liquid and solids is made up of little drops of water and little grains of land.

The total area of forest land and lands once forested but now unused and bare of forest growth in the Mississippi drainage basin is 250,000 square miles. About 200,000 square miles of such forests and forest land is far from doing what it might to hold back flood waters and prevent erosion. Some lands are in fairly good shape; some very bad shape. To rate the present water holding capacity of any but the best of these lands at 50 per cent that of a well stocked, well protected forest is generous indeed. If we reforest the bare unused forest lands and protect the remaining forests, both old and young, from fires, and prevent overgrazing, this should on the average increase the layer of humus on 200,000 square miles by two inches. Such an increase means 1815 cubic feet of water storage by each acre of forest land so improved. Applied to 200,000 square miles such improved forest conditions would give an increased water storage capacity totalling 232,320,000,000 cubic feet, or the equivalent of the entire reported average flow of the Mississippi River at Quincy, Illinois, for a period of nearly thirty-seven days.

For the purpose of assisting in the regulation of streamflow on the Mississippi, dams have been constructed at the outlet of Lake Winnebigoshish and five other lakes at the headwaters of that river, thereby creating what is said to be the greatest water impounding system in the world. These six great storage reservoirs have a total impounding capacity of somewhat over ninety-five billion cubic feet. The forests of the valley can be made to store and regulate the flow of about two and a half times the total capacity of these great reservoirs over and above the present water storage service, while at the same time increasing their value and effectiveness for wood production, outdoor recreation, and other purposes. This will not prevent floods but will reduce them.

However, water storage is not the greatest service performed by forests in the direction of flood control. More important than water storage is their influence in preventing soil erosion, which after all is the problem most vital to the Mississippi Valley. Floods in the lower valley threaten periodically a region embracing a total of 30,000 square miles, but soil erosion is nibbling constantly at the fertility of the 1,225,000 square miles of watershed contributing to flood runoff.

The whole world knows that the Mississippi flood of 1927 temporarily inundated a total of about 18,000 square miles, much of it cultivated. But few know or care that because of soil erosion 1842 square miles of plowed land in four small tributary drainage units just east of the bottom lands in Mississippi was abandoned between 1920 and 1925. Combined, the four units had a gross area of only 13,336 square miles. The abandoned plowed land of the five year period was therefore over 13 per cent of the gross area. In one unit 50 per cent of the plowed land was abandoned within the two dates.

These cases are exterme examples of what is taking place in many parts of the Mississippi watershed. In the aggregate it is reasonably certain that a greater acreage of farm land has had its value for cultivation permanently destroyed by soil erosion during the past five years by floods on the Mississippi watershed than the gross area endangered by inundation from Cairo to the Gulf.

Undoubtedly more poverty and suffering have resulted from soil erosion than from floods, but it creates no thrilling spectacle, gets no newspaper headlines and no Red Cross relief. And yet the family that is driven from its home by gully washing is a flood sufferer whose misery is no less acute because comparatively unknown.

Land with erodible soils having a slope so slight as 3¾ per cent will under the ordinary rainfall conditions of the great agricultural sections of the Mississippi Valley lose on the average, either as bare or cultivated land, twenty-three tons of soil per acre annually. The cultivation of lands with a much greater gradient, even up to two or three times as great, is not uncommon, with erosion increasing at a greatly accelerated rate.

Silt in a stream not only increases its volume but also multiplies its power to destroy. It gives it an abrasive capacity not possessed by a clear stream. Forests are the best means of checking erosion. Streams originating in timber-covered hills are clear and pure.

Forests cannot remove from the Mississippi all its great burden of silt, amounting annually to somewhere between half a billion and a billion tons. They can, however, if maintained on steep lands largely reduce this silt burden as well as assisting in regulating the streamflow. Forests cannot prevent floods on the Mississippi, but can be made to materially increase the safety factor of levees and other protection works. Reforestation would also extend the periods of usefulness of such works. It is a self-evident fact that a balance must eventually be established and maintained between the amount of silt annually received by the river between the levees below Cairo and the amount discharged into the Gulf of Mexico. If the amount received greatly exceeds the amount discharged into the Gulf of Mexico, the day of flood destruction must come sooner or later. It is cheaper and better to keep rich soil on hillside slopes by growing forests than to permit its accumulation in the river channel. This forests can do for the Mississippi River, while at the same time furnishing to the industrial population of the valley a class of raw material which thus far in human history has been found essential to progress and prosperity.

A Policy for the Mississippi

By Arthur E. Morgan

President, The Dayton Morgan Engineering Company, Vice President American Society of Civil Engineers, President, Antioch College

IN the course of the material growth of America we find, beginning about the middle of the last century, a development which is revolutionizing our civilization. It is the application to our practical problems of processes of exact and fundamental scientific analysis and synthesis, to replace the age-old methods of rule-of-thumb approximation. The searcher for ultimate beginnings may trace this process in America back to David Rittenhouse, who was described by Thomas Jefferson as the greatest mind of his age. As with a great river, there may have been many independent beginnings, all contributing to swell the main stream to a volume where it would affect our national life.

One of the early exponents of this new and revolutionizing spirit was James B. Francis of Massachusetts. About 1850, not satisfied with the crude methods then in use for the measurement of flowing water, he carried through the Lowell hydraulic experiments which became a model of clear, accurate engineering analysis.

Application of Scientific Methods to Engineering Problems

The spirit of Francis inspired the engineers of the Metropolitan Water Board, which was the agency for supplying water to Boston and its suburbs. Here, for perhaps the first time in America, we have an example of a great public engineering development carried out in a truly scientific spirit, with rigorous scientific analysis and design.

When the New York Board of Water Supply started on the great project of bringing water from the Catskills to New York City, the work at Boston was coming to completion, and Waldo. Smith, Chief Engineer of the New York project, was able to get from Massachusetts some good men already well trained in large works of that particular type, to supplement those developed in New York. The work done under his direction stands out as one of the finest applications of scientific methods to engineering problems.

In 1913, when the writer undertook to organize the engineering forces of the Miami Valley flood control project in Ohio, the water supply development in New York was nearing completion, and he was able to secure some of the men who had grown up under the influence of this great tradition. But he was no longer limited to a single source. The spirit of thoroughgoing scientific analysis of engineering problems has taken root in many places, quite largely through the work of our technical schools and universities, and the fifty or more engineers of the Miami project, gathered together by combing the entire country for men of quality, were from a dozen or more distinct fields of training. The technical reports of the Miami Conservancy District constitute a monument to their scientific spirit, and are an effort to pass on to posterity the contributions they had received from the past.

Little by little the methods of thoroughgoing scientific analysis and synthesis are supplementing, enlarging and perfecting the methods of the "practical" engineer which were based on first-hand experience and informal judgment or intuition. But the process is far from complete. Within a year the writer has been asked to pass on the plans of two great public water control projects in widely different regions, which show very little signs of being influenced by modern engineering methods.

In each case millions of dollars are being badly spent, and there is a blind fumbling about for a solution. The problems are too great to be solved by informal judgment based on everyday experience. They can only be well handled with clear rigorous scientific analysis, based on carefully collected data, and this method is as yet none too familiar to those in charge. In nearly all American engineering there is much scientific analysis of details, but it is a far cry from the rule-of-thumb work of a century ago to the modern projects where analysis is rigorous, thorough and all-inclusive, and where there is an adequate examination of every possibility. Very often we find the most conscientious and exact analysis of the details of design, while at the same time the main features are determined by guess, intuition or tradition.

RULE-OF-THUMB METHODS IN THE MISSISSIPPI PROJECT

But what has all this to do with the problem of the Mississippi? Just this, that the administration of the Mississippi furnishes the outstanding example in America of a great engineering project which still in its main outlines is being handled by rule-of-thumb methods. The problem is so vast and so complicated that it is impossible of economical mastery except by the most thoroughgoing, comprehensive and vigorous scientific analysis, and yet, considering the problem as a whole, these methods never have been applied.

Perhaps the word "never" is not correctly used, for from 1855 to 1860 two Army engineers, Humphreys and Abbot, made a study of certain characteristics of the river which still stands as a masterpiece of engineering research. But there was no apostolic succession. There has been much desultory scientific study of details on the Mississippi, but no comprehensive and exhaustive analysis or synthesis.

A brief account of Mississippi flood control may help to an understanding of the situation. Along the Mississippi River, from Cairo at the southerly tip of Illinois, to New Orleans, a hundred miles from the Gulf, the banks of the river are higher than the lands farther back. The first farming was along these high banks. Slight overflows were frequent, while very heavy flooding happened only once in perhaps five or ten years, so it was possible for planters to save many of their crops by building little dykes or levees about their farms.

THE MISSISSIPPI RIVER COMMISSION

As time passed neighboring planters joined their levees together, then the several states passed laws for the organization of levee districts, with the power of taxation, and finally the planning and direction of the whole work was taken over by the Mississippi River Commission. The Commission was organized in 1879 by act of Congress. It is headed by an Army engineer who acts as its president, and its membership includes both Army engineers and civilians. Its agents along the river are Army engineers, who are assigned to various stations and are served by civilian assistants. The assignment of army engineers to these stations generally is for short periods, until recently about two years at a station. The last position of an engineer assigned to the river might have been the administration of an Army post, or the maintenance of a harbor, so there has been small chance to develop special ability in river control. At first the functions of the Commission were advisory, but gradually, with increasing appropriations, its powers have increased.

Throughout this whole process there has been a gradual development of Mississippi control by the enlarging and coördinating of works already in existence. It has been a step by step process, always building the immediate future on the immediate past.

SUCCESSFUL PROTECTION OF THE UPPER YAZOO DISTRICT

A typical case will illustrate the methods used. The most successful of all flood control efforts along the Lower Mississippi are those of the Upper Yazoo Levee District. This district covers the territory from the north line of the State of Mississippi, just below Memphis, to a point perhaps a hundred miles south. The Yazoo Delta, which is the overflow area extending from the Mississippi River to the hills on the east, is one of the most fertile regions of America. It is the function of the Upper Yazoo Levee District to protect most of this area from Mississippi overflow by levees along the river.

About 50 years ago Major T. G. Dabney, a typical old-time Southern gentleman, became chief engineer of this district. He had good intelligence, a dominant personality, excellent political sense, and above all absolute integrity. In other levee districts the elected officials of the district employed the chief engineer. In the Upper Yazoo District Major Dabney was held in such complete confidence by the public that he ruled like an autocrat. No elected official who thwarted his purposes could long hold office.

Money raised by taxes in the Upper Yazoo Levee District was spent for building levees, and not to pay political debts. Contractors got work on their merits, and not by favoritism. An influential planter might insist that the levee be built near the river edge where it would protect his field, but if that would put the levee near a caving bank, the planter's influence would count for nothing. The levee would be set back at a safe distance.

Major Dabney so thoroughly established his policies that since his death several years ago they have been continued. Chief among these policies was the rule that the levees of this district must always be two or three feet higher than those just across the river. Regardless of the size of the flood, the levees of the Upper Yazoo District remained intact because breaks on the other side would provide outlets for the swelling waters. They have held without a break for more than 30 years.

Three conditions made this program possible: First, the integrity, economy and long experience of Major Dabney made all resources count. Second, while the district across the river was recovering from disastrous floods the resources of the Upper Yazoo District were intact and available for building more levees. Third, and of almost controlling importance, the belt of land to be protected back of the Upper Yazoo levees was wider than in other districts, so that a greater number of acres was available for taxation to build each mile of levee.

WEAKNESSES OF THE OLD SYSTEM

Here we had the old system at its best. But it was a rule-of-thumb system. Major Dabney did not know how much water might come down the Mississippi. He did not know how high his levees would have to be if all other levees should be as high as his. He did not know the silt-carrying capacity of the river nor the exact conditions under which disturbances of flow would take place. As to the feasibility of reservoir control, he was certain there was nothing in the idea, although he knew very little about the presence or absence of sites for such reservoirs, and, I believe, had never understood the principles on which they would best operate.

The writer once spent a month with Major Dabney, and found him to be a man of high intelligence, wide reading, and keen discrimination, but the modern method of rigorous, fundamental and comprehensive analysis was not his. He had never been introduced to it.

That same fundamental criticism holds against almost the entire administration of the Mississippi River. There has been a vast gathering of data, and with reference to many details there has been excellent scientific analysis. But taking the problem in its entirety it has been handled by observance of traditional dogmas, arbitrary rules and unproven axioms. The immediate future has been guided by the immediate past. No one comprehended and mastered the whole problem of the river. Comprehension of the whole problem was impossible, for the data never had been gathered on which such an understanding could be based.

A few specific cases will illustrate this point. After the great flood of 1897 the Mississippi River Commission established a standard levee grade for the entire river below Cairo. This standard grade was to be three feet above the height the water of 1897 would have reached if confined between levees. Now there are several great tributaries entering the Mississippi—the Upper Mississippi, the Missouri, the Ohio, the White, the Arkansas, and the Red. In 1897 some of these were greatly in flood, and others were not. To plan the levee system as though the 1897 flood was typical of all floods was certainly rule-of-thumb engineering.

In 1912 another great flood occurred, and again the levees were broken. (They had not all been brought up to the 1897 standard.) Thereupon a new standard levee height was adopted by the Commission, which was three feet above the 1912 high water, similarly determined. In 1927, as might have been expected, there was a very different distribution of flood waters in the different tributaries, and the rule-of-thumb grade line of 1912 did not fit.

THE "LEVEES ONLY" POLICY

In the choice by the Mississippi River Commission of agencies for flood control there is a long tradition of similar rule-of-thumb methods. About 50 years ago the Commission adopted a policy of "levees only." No conclusive study ever had been made of other methods. The writer has step by step followed back the history of these arguments, in government documents and in technical literature, and always he has found generalizations, assertions and hazy references to former thorough studies, but never any evidence of the studies themselves.

The recent national meeting of the American Society of Civil Engineers, October, 1927, was largely given over to a discussion of the Mississippi problem. At that meeting there was presented the embarrassing spectacle of engineers of national reputation and long experience proposing widely varying and conflicting solutions to this great problem. The reason for this conflict and confusion is that no one is in possession of the facts.

The Mississippi River Commission, in its absolute faith in the traditional doctrine of "levees only," has held that, except for working out conditions relating to levees and bank revetment, it had all the facts necessary, and has discouraged the thorough, patient and widespread work which must be the basis for any adequate and economical plan. Its members have stated repeatedly and unequivocally that there is no material uncertainty about the cost of complete and final protection. It has discouraged thorough investigation by its statement to the effect that the work was rapidly approaching final completion. Yet today it is unquestionably true that never in the history of the Mississippi River Commission have its estimates of the cost of completing its work been more than 10 per cent or 20 per cent of the true cost. That tragic result of rule-of-thumb engineering would have been unnecessary if the methods of modern engineering analysis had been in control.

A THOROUGH STUDY OF THE PROBLEM NEEDED

What should be done?

First, we should know the facts. Second, we should have a scientific analysis and interpretation of them. And, third, after a comparison of all possible methods and combinations, a comprehensive plan should be adopted.

An emergency is to be met, and first of all we should know what is necessary to bring the river back to its past stage of control. Already much of this work is being done.

With the immediate emergency cared for, the necessary time should be taken and expense incurred to make a study of all phases of the river problem, and to prepare plans for permanent control. Such a study probably would take ten years or more, though much effective work will be possible during that time.

USE FOR A HYDRAULIC LABORATORY

We must understand the behavior of the river. To this end a part of the necessary studies can be made best on the river itself, and part in a hydraulic laboratory. The establishment and maintenance of such a laboratory would help greatly to solve many perplexing problems of river control. It is possible on a small scale to discover many of the laws and characteristics of water flowing on a large scale. Some of the finest hydraulic design ever worked out under the writer's direction was developed by that method.

Along with the hydraulic laboratory there should be a far more thorough and intimate study of the river than has ever been made. At what velocities does it deposit silt? At just what velocities and under just what condition does it cave its banks? To what extent does the whole river bottom move during high water? What would be the effects of outlets and spillways? What conditions are necessary to prevent a shallowing of thé channel?

We need to know more about the origins and possibilities of floods. How much has each tributary contributed in the several floods? (Far too little is known on this point.) What is the probable maximum flood on each tributary in 10, 25, 50, 100 and 500 years? What is the probability of coincidence of floods on various tributaries? How would such coincidence affect floods on the main river? What is the effect of levees on these lower tributaries in forcing the water into the main river?

A STUDY OF VARIOUS METHODS NEEDED

We need to know about the feasibility and value of every possible method of flood control on the Mississippi, and of every possibility of combination of different methods. It might seem on first thought that this would mean an endless job of comparing an infinite number of possible combinations, and that no final and conclusive *best* ever could be reached.

This is not the case. Such an analysis can proceed from the smaller components to the greater, with the orderly, methodical elimination of the less desirable methods, so that the problem moves surely and steadily to the one best solution, which probably will be a combination of many methods. So far as the writer is aware, the first clear statement of such a process of large scale definitive engineering analysis is given in the technical reports of the Miami Conservancy District.[1]

There must be a study of the possibility of diversions and outlets from the main river and from its tributaries, of reservoir control, and of spillways, as well as of control by levees and revetments. There has been much heated argument for and against these alternative methods, but no adequate study of them. There must be a study of the greatest possible combination of flood which it is wise to protect against, and of the methods and devices for limiting damage in case that maximum is exceeded.

For 50 years the public has been made to believe that the Mississippi problem lay in a choice between levees and other methods. Such is not the case. A final correct design without doubt will be a combination of several methods, each used in the places and to the extent that is most effective.

There should be a study of the responsibility for flood damage, to determine whether and to what extent any habits of the northern states have increased flood damage below. The writer is of the opinion, from the most careful study available, that the case of the Lower Mississippi against the north in this respect is almost absolutely unsupported by any evidence. If there is such evidence it should be discovered and carefully weighed.

Unless the Lower Mississippi is to become permanently a pauper region to be cared for by the National Government, there should be a study of the equitable distribution of the cost of protection.

NEED FOR A REVIEW OF THE LEGAL NECESSITIES

The legal necessities of the whole situation should be reviewed. The writer believes that an amendment to our National Constitution may be necessary to give the National Government the power to do work wherever it is most necessary and to assess the cost in an equitable manner. We are now living under a hypocritical fiction. Improvement of navigation, being under federal control, is made the excuse for flood control. By gradual accumulation of precedent we are, in fact, amending the Federal Constitution, but in such a partial and inefficient manner that the Federal Government is acquiring obligation for flood control without the necessary powers for its proper execution. To try to solve the problem of the Mississippi without improved legal machinery will result in distortion and monstrosity. The legal structure of flood control should be as well built and as comprehensive as the engineering design.

Such are some of the types of information that should be collected, and of preparation to be made. Perhaps ten years will be required under good administration to accomplish those purposes.

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[1] "Hydraulics of the Miami Flood Control Project." Technical Reports, Part VII, Chapter XII. Published by the Miami Conservancy District, Dayton, Ohio.

Given the information, the task remains of synthesizing a comprehensive program. During the whole period of preparation this synthesis would be made tentatively again and again to throw light on the process of gathering information. When a general plan is finally adopted by this method it will have the respect and confidence of the engineering profession and of the nation, and there will not be the conflict of opinion among representative engineers that now characterizes a discussion of the Mississippi problem.

A HASTY SURVEY IS INADEQUATE

The hasty survey now being made by the War Department, in an effort to make up for half a century of unfounded assurance, cannot accomplish in a year or two what is necessary for the preparation of an adequate plan. To present a plan to the present Congress that would, in fact, commit the nation to a far-reaching policy for the Mississippi, would be a great national disservice.

The more courageous and honorable attitude would be to face the issue and to inform the American public of the true facts. It is not impossible that, by the premature adoption of a policy for the Mississippi, the country may be led to the wasting of hundreds of millions of dollars, to find itself 20 or 30 years from now faced with another tragedy, and still lacking the fundamental information on which an adequate plan can be based.

No similar problem of similar size ever has been mastered by men. The issues transcend rule-of-thumb methods. Only a thorough analysis into fundamental elements, with a new and creative synthesis, is adequate. Just as the architect of the skyscraper had to escape from the stone mason, and as the railroad creator had to escape from the horse and wagon, in order to fulfil their destinies, so the engineers who conquer the Mississippi must be able to see over the tops of the levees and to think and to design as scientists. They must stoop to the study of minutest elements, and must reach to a mastery of the whole. That attitude has yet to be in evidence.

Some Essential Principles of Water Conservation

As Applied to Mississippi Flood Control

By Hon. Gifford Pinchot
Formerly Governor of Pennsylvania

THE first need of life on this planet is water. A man can live nearly as many weeks without food as he can live days without water. Moreover, it is the supply of water, and not the area of land, which will limit the number of people who can live in the United States. We have land enough for vastly greater crops and hence for a vastly greater population than we have water enough to sustain or produce.

Running water in rivers and source streams, therefore, is the most important of all natural resources, more important in certain ways even than the forest, and that is a large admission for a forester. Twenty years ago the studies of McGee showed for the first time the real position of water in the economy of the Nation.

Not only food supply, but the supply of clothing and the supply of wood are dependent upon the presence of water in sufficient quantity for vegetable growth. Water, moreover, is a cheap carrier of bulky goods, a source of vast and perpetual mechanical power, a carrier away of noxious wastes, and a giver of health, vigor, and delight through recreation.

At the same time water uncontrolled may become a destroying agent of the first rank. The greatest natural calamity in the history of the United States is the recent Mississippi flood. That such calamities are confined to no one river system is proved by the still more recent disaster in northern New England.

Soil conservation is largely water conservation. The prevention of erosion is a question of handling water, while the getting or foregoing of new acreage through swamp drainage likewise depends upon the handling of our water supply.

In dealing with water, the law gives the public a freer hand than in dealing with other natural resources. Land, for example, may be owned absolutely in fee simple. But running water in its nature is a fugitive thing, and it is not subject like land to absolute private ownership.

You may use the stream which runs by your door, but it is not your stream. Others have rights in it also. The law, consequently, gives the state large powers over it, much larger than any powers the state has over land.

As to water, the public right is dominant, the private right subservient. Moreover, wherever its use affects navigation, albeit indirectly, the authority of the Federal Government is supreme.

We have made but a poor use of these large public powers over water. Our dealings with our rivers have been haphazard, uncoördinated, wasteful, political. It is well to remember that famous river in Texas where it was proposed to spend the money of the Nation not only to dig a navigable channel, but to build pumps enough to put water in the channel when dug.

Our dealing with water has been the result of viewpoints and habits acquired when we had abundant water supply for a sparse population in a humid climate. These habits, legal and otherwise, were found to be unsuited to the same sparse population in an arid climate. We were obliged to adopt legal principles outside the English common law to meet physical conditions outside the experience out of which that common law had sprung. Eventually we shall have to consider how far the common law principles have become unsuited to a dense population even in a humid climate, but that time is not yet.

Nation, state, municipality, corporation, and individual citizen have each dealt with water here and there from time to time as need arose without comprehensiveness of view, consistency of purpose, unity of method, or coordination of effort. The times are ripe for a change in policy.

Two decades have passed since Roosevelt's Inland Waterways Commission, in a sane and courageous report, summoned all men of intelligence and vision to unite behind a wise and foresighted policy for the control and development of our river systems. Such a policy, to take the place of the selfish, scrambled, local policies which have hitherto stood in the way of the comprehensive and effective development of our rivers, must be built upon principles or considerations such as the following:

WATER CONSERVATION PRINCIPLES

Every stream and every river system is a unit from its source to its mouth, and common principles and one general policy should control in all uses of it and dealings with it throughout its whole extent.

The common plan and policy should take carefully into account all of the different ways in which water can be made to serve mankind, such as domestic water supply, industrial processing, sewage and waste disposal, irrigation, draining, power, navigation, and recreation.

When any of these uses are mutually exclusive, preference must always be given to the higher use over the lower, usually in the order of domestic supply, waste disposal, irrigation, power, and navigation.

All uses of the water and benefits to be derived from its control should be kept carefully in view. One of the greatest dangers to wise and effective stream development is that undue emphasis on local or temporary advantages will make forever impossible the complete utilization of the resources of the stream.

The authority and undertakings of Nation, states, municipalities and individuals should be pooled to attain a common object and execute the several parts of a common program.

In executing such a common program it is of the first importance that all existing National, state, and municipal public rights of control and public property rights shall be maintained unimpaired.

In establishing control of any stream or any river system for flood prevention or any other purpose, every useful and available means of establishing such control, including levees, spillways, soil conservation, forest conservation, storage reservoirs, and any others should be considered and made use of to the fullest practicable extent.

In all projects for stream control, the feasibility of securing repayment, in whole or in part, of the expense of such control from the development of electrical power through storage and other reservoirs, and from assessment of resource values directly created by such reservoirs, should be fully considered and put to use when available.

The execution of the new policy and plans under it should be taken wholly out of politics and put beyond the hazards of annual appropriations.

The allotment of costs between the

National Government and local interests should be established in each case upon the basis of the local benefits to be conferred and the ability of the localities to pay.

THE KIND OF COMMISSION WE NEED

The foregoing brief statement indicates partly, but only partly, the complexity and reach of the problem of controlling such a river system as the Mississippi River. As the largest conservation problem ever undertaken by any nation, and as affecting most vitally the vast central valley of the United States, this gigantic adventure of bridling the Mississippi deserves the best skill and experience this country can provide.

The Mississippi problem is the biggest half of our waterways problem and it consists of two parts. The first concerns immediate relief for the situation of the moment; the other, the permanent cure of floods and the complete utilization of the Mississippi River system. The preparation of a plan for the latter should be attempted only under the direction of the most competent men this nation can supply.

My suggestion is that a commission consisting of the foremost engineers and experts in every one of the lines involved—electric, hydraulic, forestal, agricultural, social, financial, and any others—should be selected for two purposes: First to acquire or assemble the necessary basis of fact concerning the Mississippi system—facts which the Army Engineers have most unfortunately neglected to secure; and secondly, upon the basis of these facts to prepare a general plan under which this vast undertaking may fairly be expected to produce results.

It is now proposed by certain interests to entrust this enormous task to the Corps of Army Engineers through the Mississippi River Commission, which it dominates. These two bodies, by their insistence on the policy of levees only, long after repeated disastrous floods had proved it unsound, have committed, in my opinion, the most colossal engineering blunder in human history. To leave the future of the Mississippi in the hands of these same men would be to certify failure in advance.

If this plan to employ the foremost experts in this, the foremost conservation enterprise of mankind, is sound, then the same general procedure will apply, in its degree, to other similar but smaller undertakings. The essential thing is to make use of the best we have in knowledge, experience, and achievement, and to learn from the blunders of the past how to avoid falling into the same pit.

The St. Lawrence Waterway Project

By Fayette S. Warner
University of Pennsylvania

THE St. Lawrence Waterway Project, from the engineering point of view, consists in the canalization of the St. Lawrence River, making it available to ocean-going vessels, from Montreal Harbor to Lake Ontario.

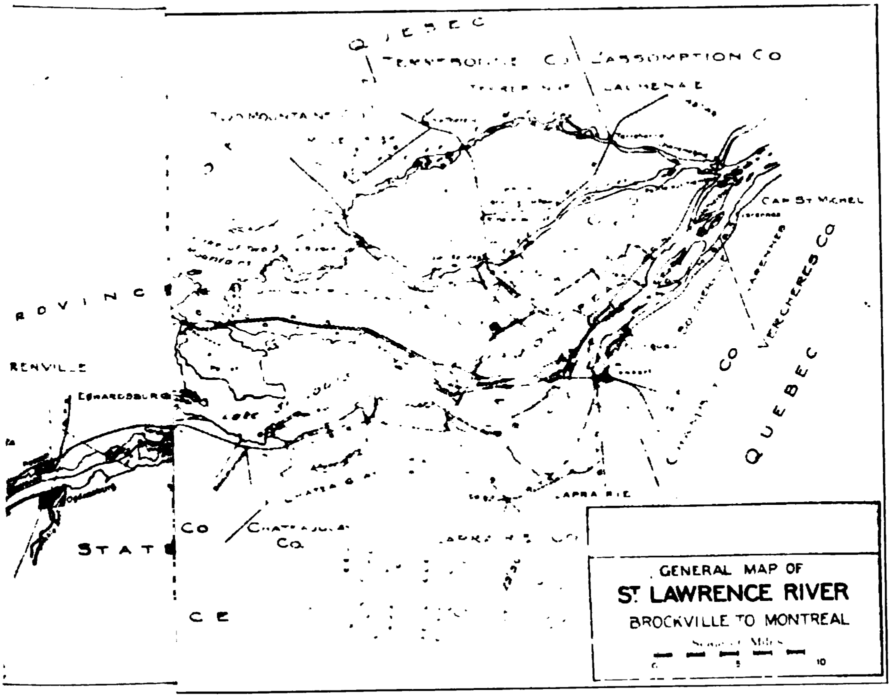
This portion of the river, a distance of some 182 miles, flows over an undulating plain in which it has carved scarcely any valley. The river has an average width of about a mile from Cornwall to Lake Ontario. Below Cornwall (Plate I), it widens to five or six miles in three places, forming Lake St. Francis, Lake St. Louis and the La Prairie Basin, which are connected by the famous Cedar and Lachine Rapids, respectively. A series of rapids occurs above Cornwall which extends up the river to Prescott. The rapids are caused by the river flowing over bed rock formation which outcrop at these places. It is the drowning of these rapids by building dams at certain proposed points, thus creating large tranquil pools and the connecting of these pools and lakes, with canals and locks, which forms the main engineering problem to be solved. To the engineer the problem is not unsolvable.

Starting from Montreal Harbor, the first division of construction necessary will need to overcome the rise of 8 feet to the level of La Prairie Basin, the drowning of the Lachine Rapids by building a dam near the vicinity of Heron Island and dredging the shoals at the lower end of Lake St. Louis.

It is proposed to locate the first lock about 2000 feet down stream from Victoria Bridge and just north of the Mackay Guard Pier, as shown in Plate II. The locks are to be the same size as those at the New Welland Canal, which climbs the Niagara Escarpment, and will be completed by 1930. These locks are 860 feet long by 80 feet minimum width with sills for 30-foot draft. This lock will raise the level to an elevation of +52 feet.

It might be added that it has been proposed to build a low dam just south of Victoria Bridge and raise the level of La Prairie Basin, using it as a part of the course and gain the use of the low head for power. This plan probably will not be carried out because of the very long dam to be built; the excessive amount of dredging necessary to gain the ship channel; the excessive amount of dike building around the basin and the town of La Prairie in order to protect it from inundation during periods of heavy flow; the necessity of buying a large acreage to prevent property damage; the probable loss of the use of the power-generating units when ice jams occur in the lower St. Lawrence, causing the flood waters to set back over the dam. The return from this low head development would not be great enough to offset the costs.

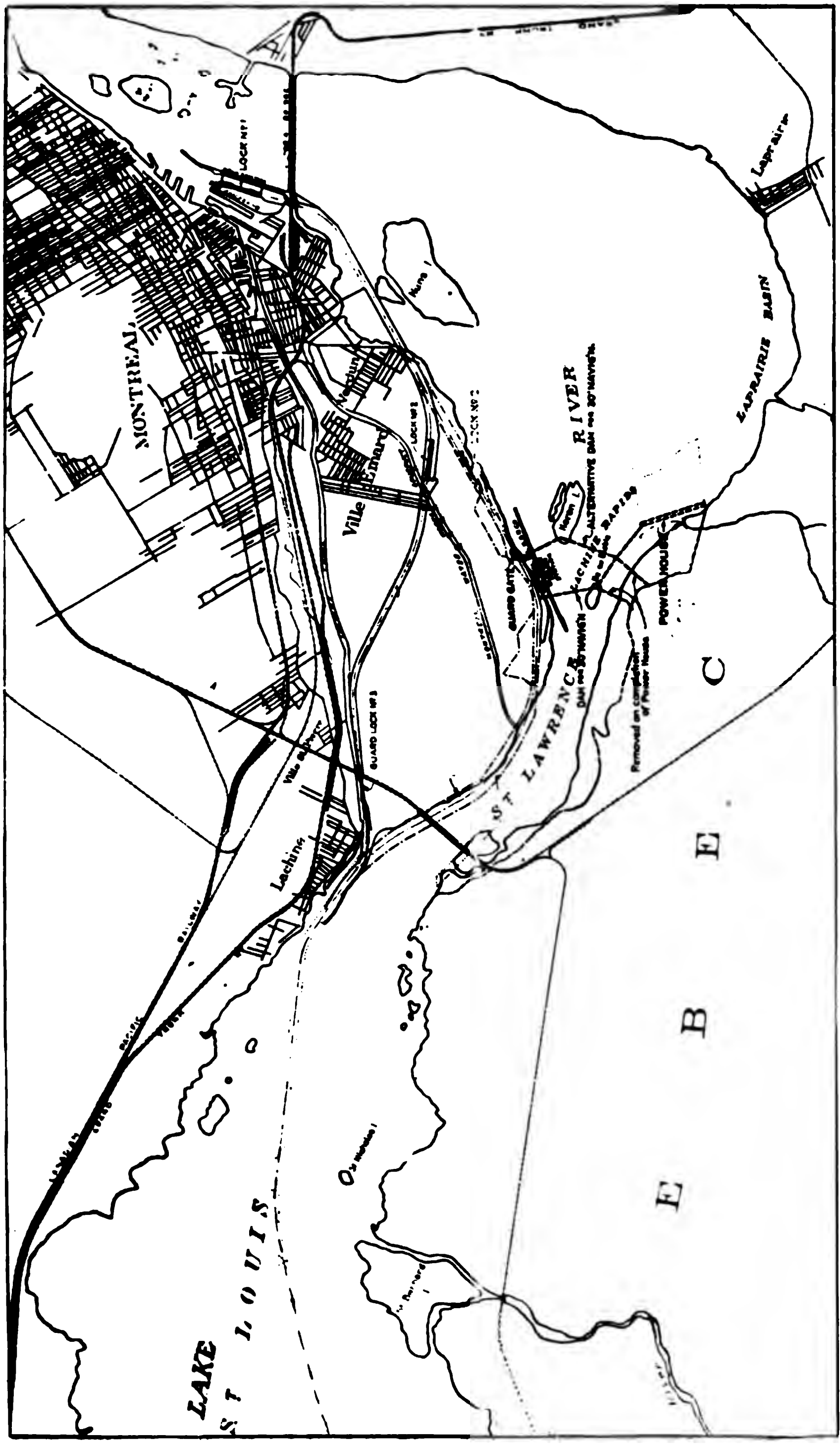
From Lock No. 1, the course of the route will probably pass through the west approach to Victoria Bridge, necessitating the building of probably two lift bridges to carry a total of three railroad tracks, one electric line and the highway. From this point the course will follow the shore line approximately, passing to the west of Nuns Island. On the river side of the canal a concrete retaining wall backed by an earth fill toward the river and paved to provide against damage by ice and wave action is proposed.



GENERAL MAP OF
ST LAWRENCE RIVER
BROCKVILLE TO MONTREAL

PLATE II

Div. 1



THE LACHINE RAPIDS DIVISION OF THE ST. LAWRENCE PROJECT

There is already a dike on the Montreal side of sufficient height and size to protect the riparian property which will serve as the land bank. It will be necessary to pave it against wave action.

This course continues practically in a straight line about a mile past the village of Verdun, where a second lock will be located. This lock will raise the elevation to that of Lake St. Louis. This plan calls for a dam across the Lachine Rapids some 4000 feet beyond the lock and in the vicinity of Heron Island. Its exact location will be determined by the cost of construction and maintenance of the temporary diversion dam during the construction period.

There seems to be an excellent foundation of rock averaging 2½ to 5 feet beneath the surface of the rapids extending out from both banks from 1000 to 1300 feet. These portions of the dam, then, would be relatively easy to construct. The remaining portion would offer greater difficulty, as the Canadian District Engineer[1] pointed out, because the whole river seems to rush through a gap some 400 feet at a rate of about 30 miles per hour. Several soundings were taken which seemed to indicate that there were several points in the gap which were 200 feet deep. Another heavy cost to be thought of will be the large amount of earth and rock to be removed in order to carry the volume of water to the probable location of the power house, and the still heavier cost of excavating the rock for the tail race, as it is as necessary to take the large volume of water away from the turbines as it is to bring the water to them, in order that they may operate efficiently.

This development will give about 700,000 horsepower, which, according to the District Engineer, could be absorbed by the industries at Montreal and vicinity immediately, if it were available.

The canal channel from the dam to Lachine Wharf will follow the shore line. At this point it will enter the deep water of Lake St. Louis, where there is a stretch of 14 miles of almost unrestricted sailing. The cost of this project is estimated at about $145,000,000.

It is a little less costly for this portion of the route if both the power development and waterway are developed together since there is a demand for the power. If the demand for the power did not exist, it would be less costly to develop the waterway on an inside land route through Ville Emard to Lachine.

The inside route contemplates the power development coming at a later date; but the initial cost of each would be greater, developing them separately than to use the above described route which contemplates developing both the power and Lachine Rapids route at the same time. It is also to be noted that the inside route will be only a 25-foot channel until the power project is completed, whereas the Lachine Rapids route with the power development will be a 30-foot channel from Montreal Harbor through Lake St. Louis.

The second division (Plate III) of construction is the connecting of the upper end of Lake St. Louis with the lower end of Lake St. Francis. The difference in level between the two is 83 feet, Lake St. Francis being at a level of +152 feet.

These two lakes are separated by a series of three rapids, Coteau, Cedar and Splitrock Rapids, over a total distance of about 16 miles. It is possible, and the foundations are such that dams can be built at the foot of each rapid, thus ponding the water. However, this idea can be immediately dis-

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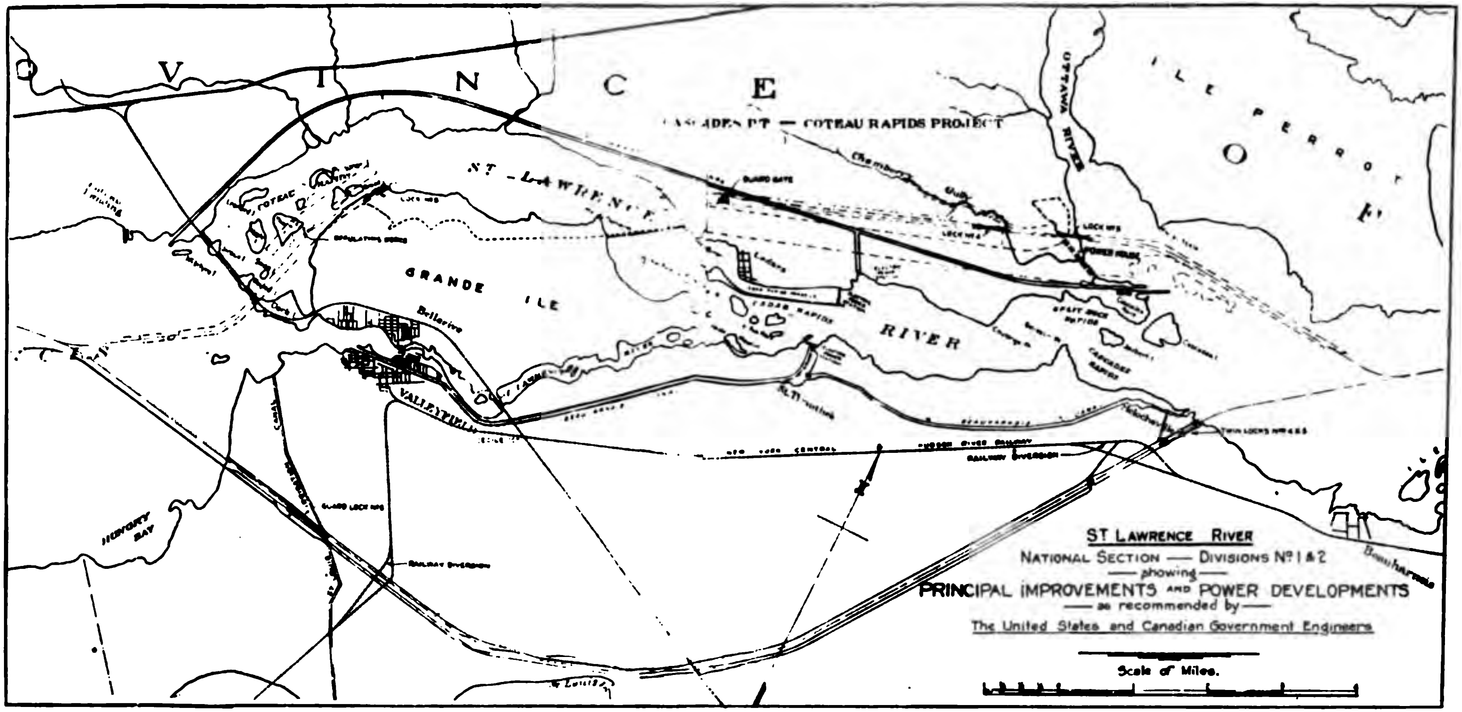
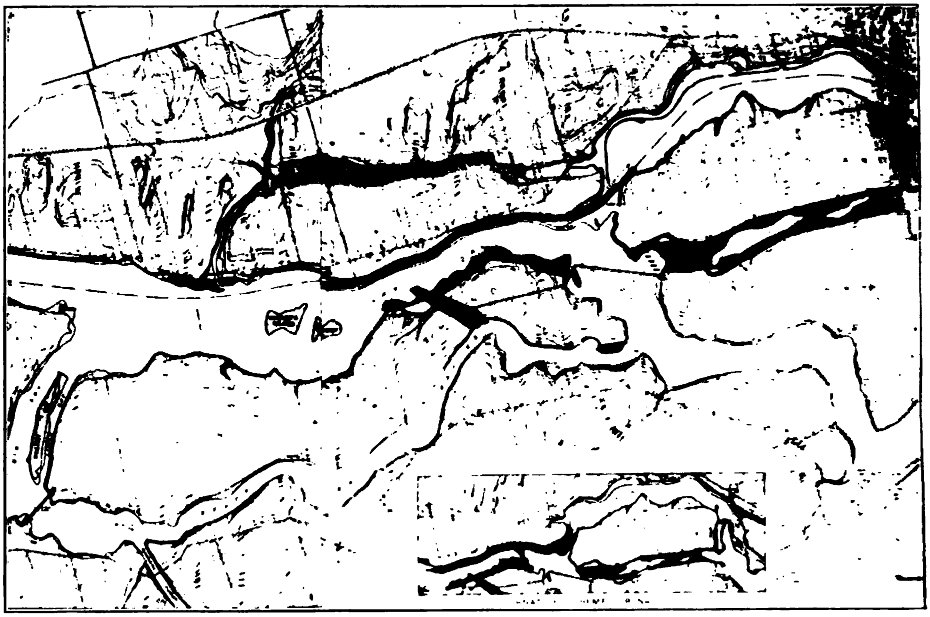
[1] District Engineer Yule.

PLATE III



Div. 2

PLATE IV



THE BARNHART ISLAND DEVELOPMENT AT CORNWALL — INTERNATIONAL SECTION

missed from practical consideration because of the enormous cost of building diversion dams for the construction period.

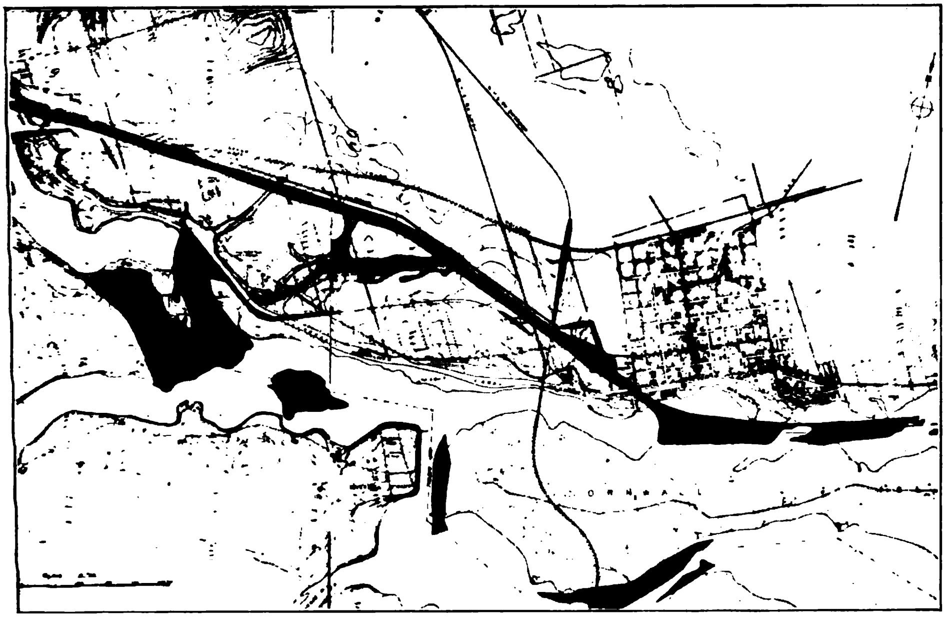
It has been proposed to build a canal around the rapids on the south side of the river. Entrance from Lake St. Louis is near Melocheville. The locks of 41-foot lift each are located not far from the village which will raise the level to that of Lake St. Francis. The foundations of these locks will rest on bed rock. The canal will then continue in a straight line for about six miles, followed by a series of gentle sweeping curves to the right for a distance of four miles. A tangent of three miles brings the canal to the shore of Lake St. Francis.

It will be necessary to dredge a channel of two miles to deep water in Lake St. Francis. The entire canal can be built through Champlain clay with a width of 450 feet at the top, a depth of 30 feet, and a provision for widening to 600 feet in the future at a cost of $40,000,000. This includes all costs, bridges, railroad fills and guard locks at Lake St. Francis. Power can be developed at a later date without any interference with navigation at a cost of $152,000,000 for 1,560,000 horsepower.

If power is developed at the same time that the waterway is built, then another scheme can effect a saving of about fifteen million dollars to the development of power. This scheme can be carried out on the north side of the river, by constructing a dam across the river above the town of Cedars from Point a Brion to Point du Domain, and building a large power canal running back of the village of Cedars to a power house located just north of the point where the present Soulanges Canal enters Lake St. Louis.

The new ship canal would lie north of the power house with the first lock at the entrance and the second further up Chamberry Gully. The plan would

PLATE IV



Div. 4 — Lower Dam

necessitate a guard lock between Broad Island and Grande Island, with an embanked channel and regulating works at Thorn Island; also, dredging from Thorn Island to Prisoner Island in order to care for the heaviest floods and winter conditions.

This plan contemplates a 30-foot channel for $55,000,000 with a very easy power development at a later date at a cost of $125,000,000, or at a total of $180,000,000.

It seems likely that the demands for power will be so great by the time that this project will be completed that it will pay to embark on the second scheme of development rather than the first.

The Third Division of construction is the deepening and widening of the channel through Lake St. Francis. It is a distance of 28 miles and a channel 450 feet wide by 30 feet deep is estimated to cost $1,820,000.

The Fourth Division (Plate IV) of the development, known as the International section of power development, comprises a distance of about 50 miles between Cornwall and Prescott.

The scheme that will probably be used is known as scheme "B" in the International Joint Commission's report which provides for the least amount of land inundated. This scheme calls for a two-stage power development making the total amount of land inundated 6000 acres.

The lower dam and power houses will be located between the lower end of Barnhart Island and the mainland on the Cornwall side intersecting Lock No. 20 of the present Cornwall Canal some three miles above the village. Another dam in this series is to cut off the main Long Sault Rapids and is located at the upper end of Barnhart Island to a point near the lower end of Long Sault Island.[2] The third dam will regulate the flow to the Massena Power Canal and connects the upper end of Long Sault Island with the eastern shore.

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[2] The investigation of foundations by tunneling under the river was being carried out by U. S. Engineers in the summer of 1925.

It will be necessary to carry out considerable dredging and enlarging of the channels in order to care for the volume of water at the several points in this portion of the development. The cut at Polly's Gut must be enlarged in order to care for the swift water and to lower the velocity of the river on the north side of Cornwall Island. A large amount of earth and rock removal are necessary at the Barnhart development; also, the channel must be widened and deepened between Shiek Island and Barnhart Island to bring full delivery to the forebay of the power house. An additional channel and control dam will be placed near the lower portion of Long Sault Island to care for extreme high water and to divert the flow during construction of the Long Sault dam. The proposed waterway channel necessitates a large amount of dredging to be carried out on the north side of Cornwall Island from the upper end of St. Regis Island to a point just southeast of the village where Lock No. 7 will be located. This lock will carry the level to elevation +200 feet. The canal will continue overland for about three miles to Lock No. 8, which will have a life to elevation +210; again continuing in a straight line to the stillwater north of Shiek Island which is created by a dam from the lower end of Shiek Island to the mainland and a dam which already exists from the upper end of Shiek Island to the present Cornwall Canal embankment. From this point to Morrisburg (Plate V), it is practically open water, but it will be necessary to do some dredging between Weaver's Point and the entrance to Lock No. 9 which will be located about a mile west of the village. A dam will be built at this point from the mainland to Ogden Island, from Ogden Island to Clark Island, and from Clark Island to Murphy Point. Two power house developments will be located on either side of Clark Island, while the sluiceway and spillway will be in that portion of the dam that crosses the main section of the river. The Morrisburg dam raises the elevation to +242 feet, thus creating stillwater with only the proper amount of gradient from Morrisburg to Lake Ontario. Some dredging will be necessary above Morrisburg in order that the full amount of water may be easily discharged under a low velocity as it is now being discharged under the high velocity of the rapids. The total amount of water power developed at Barnhart is 1,250,000 horsepower and at Morrisburg 600,000.

The total cost of this division including power, 30-foot navigation and all damages, is estimated to be $212,000,000.

The Fifth Division, from Chimney Point to Lake Ontario, is 65½ miles long, with a fall of about one foot. The channel is deep and wide, having a minimum width of about 500 feet through the Thousand Islands. A few points of rock found above grade of 30-foot channel can be removed for an estimated cost of $100,000.

The total improvement, as outlined, is estimated to cost about $539,000,000, of which about $125,000,000 is chargeable to navigation, and $414,000,000 to power, averaging about $100 per horsepower developed.

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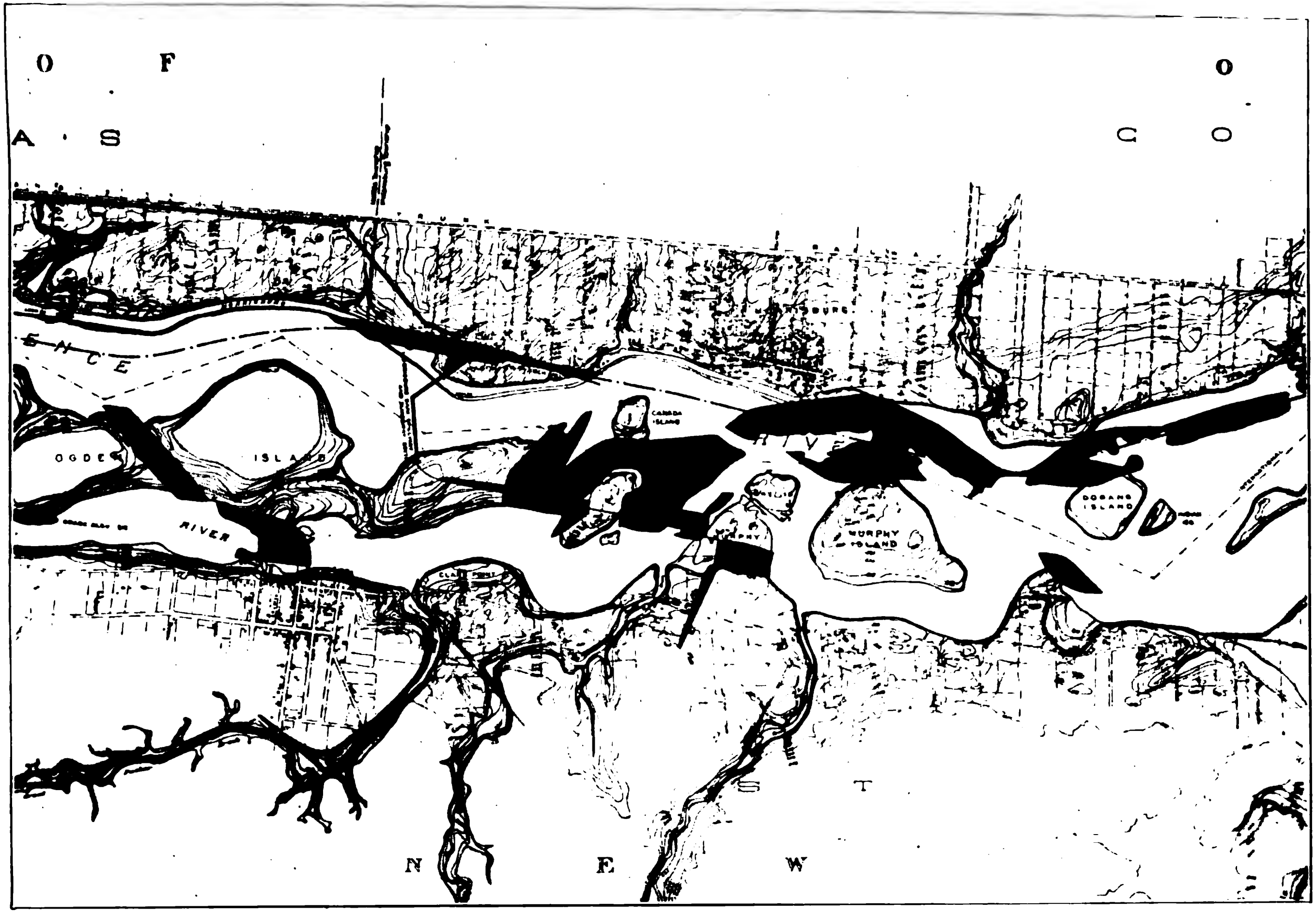

THE MORRISBURG DAM — INTERNATIONAL SECTION

Div. 4 — Upper Dam

A Synopsis of the Hoover Report on the St. Lawrence Shipway

By Fayette S. Warner
University of Pennsylvania

The President appointed a Commission March 14, 1924, to advise upon the development of a shipway from the Great Lakes to the sea. He named the following men to the Commission:

Herbert Hoover, Chairman
William C. Brood of New York
James P. Goodrich of Indiana
James E. Davidson of Michigan
Charles L. Allen of Massachusetts
James R. Howard of Iowa
James P. Noonan of Missouri
Stephen B. Davis, Counsel
Charles P. Craig, Executive Secretary

In 1919, the International Joint Commission between United States and Canada made an investigation of the proposed river improvement between Montreal and Lake Ontario, setting forth its conclusions and recommendations in a report under the date of January 6, 1922. That Commission endorsed a plan for improvement of the St. Lawrence River and recommended that further study be made of the economic and engineering features. Therefore, in accordance with this recommendation a Commission was appointed by the President and a similar one by the Canadian Government known as the National Advisory Committee of Canada. It was agreed by the two governments that a Joint Board of six engineers should be created and a complete survey be made.

By the Rivers and Harbors Act, approved March 3, 1925, an item of $250,000 for this survey was allotted and the Board of Engineers of the United States Army were directed to make the examination.

The Department of Commerce, at the request of the Commission, undertook a full examination of the economic questions involved and its report was completed and transmitted in January, 1927.

All this data together with numerous studies on the part of the members of the Commission have brought it to the following conclusions:

1. The construction of such a shipway from the Atlantic to the Great Lakes, as is proposed, will be of great economic benefit to the lowering of present transportation costs to the interior of the continent and particularly to the region around the Great Lakes. This territory embraces the following states: Ohio, Indiana, Kentucky, Illinois, Iowa, Missouri, Kansas, Nebraska, North and South Dakota, Montana, Wisconsin, Minnesota, Michigan, Pennsylvania and New York. It also includes a large part of Canada.

More than forty million inhabitants not only gain their livelihood from the basic industries within this territory, but produce a large surplus both from agriculture and manufacturing.

The building of the Panama Canal brought the eastern coast nearer to the western in cheaper rates. But the gain was of much greater advantage to the eastern coast region than to the interior.

If we take for illustration the cost in cents carrying a ton of staple goods at the present rate, using the cheapest route, we find that previous to the war, New York was 1904 cents away from

San Francisco, while it is now only 1680 cents. Chicago, which was 2610 cents away from the Pacific coast before the war, is now 2946 cents away. In other words, Chicago has moved 336 cents away from the coast, while New York has moved 224 cents nearer.

Similarly it can be shown that Chicago has moved about 594 cents away from the markets of the Atlantic Seaboard and South America. This same ratio applies to other mid-western points.

The increases in rates have affected this section from 6 to 18 cents per bushel upon grain, while similar increases have not taken place in competing countries, which have greater access to the seaboard. Hence, this deduction of freight rates comes out of the mid-continent farmers' receipts. The effect of completing such a shipway as the proposed St. Lawrence improvement would be to gain a substantial reduction in the cost of transportation, and would be a direct cause for raising the price levels of all grain in the lakes transportation area.

Other industries would be affected by the same type of economic reaction. It has been estimated that the returns in a single year to the farmers would equal the capital cost of the waterway.

2. There are three different routes proposed:

(a) The reconstruction of the present canal from Lake Ontario to the Hudson, using the new Welland Canal now under construction by the Canadian Government to connect Lake Ontario and Lake Erie. The United States has treaty protection in equal treatment in the use of the Welland Canal.

(b) An "All American" route, which would use the same route, but would construct a new ship canal on the south side of Niagara which would duplicate the Welland Canal.

(c) By using the St. Lawrence River under joint agreement with Canada.

3. Depth of Shipway. It is proposed to build all permanent structures for a depth of 30 feet, but to make the connecting canals only 25 feet, as that draft will at present admit 88 per cent of all ships entering American ports.

The capacity of this canal is estimated at 30,000,000 tons per year if a single chain of locks is used. This capacity can be increased to almost any desired amount by constructing parallel locks.

4. The Department of Commerce estimates the following tonnages by routes:

	Minimum Tons	*Maximum* Tons
Ontario-New York route	15,000,000	20,000,000
St. Lawrence route	21,000,000	25,000,000
Median..........	17,500,000	23,000,000

80 per cent represents imports and exports.
20 per cent represents internal traffic.

5. The United States Engineers report of December 6, 1926, estimate the cost of construction of a ship canal: Lake Ontario-Hudson route, $506,000-000; All American route, $631,000,000; St. Lawrence route, $123,000,000 to $148,000,000, depending upon the quantity of hydro-electric development. The All-American or Lake Ontario-Hudson routes would not develop power.

6. The development of the St. Lawrence for power is inevitable. Complete development will give about 5,000,000 installed horsepower of which 2,250,000 horsepower lies in the international section. It is profitable to develop this river for power, and this would eventually create a shipway even though the other routes are undertaken.

7. The requirements for power by the Province of Ontario, New York

and New England States will be great enough by the time the project in the international section is completed to absorb the entire output.

The development of power of this section with an additional expenditure from $22,000,000 to $34,000,000, depending upon the details as to whether it is a two-stage or single stage, for locks and canals would carry the shipway 141 miles out of the total 183 miles from Lake Ontario to Montreal, or within 42 miles of tidewater. There are two plans, first, by building a shipway around the rapids completely independent of any future power development, and second, by making use of a partial development in order to offset future costs to the complete development of power.

The first method will cost about $97,500,000, while the second would cost about $161,000,000. The second method is recommended by the Joint Board of Engineers.

9. It is possible that other agencies than the governments themselves will be given the right to develop the power. However, the undertaking is of such a nature that the power development and navigation project will probably be carried out as a joint one between the United States and Canada.

The method as to how the costs shall be shared by the two countries has not been determined.

10. Comparison costs of maintenance with interest at 4½ per cent of the three routes are:

	Per Year
All-American	36,000,000
Lake Ontario-Hudson	28,770,000
St. Lawrence	$10,000,000

These estimates applied to the annual tonnages on these routes are:

	Per Ton
All-American	$2.06
Lake Ontario-Hudson	1.64
St. Lawrence	.43

11. Comparison of restricted navigation routes:

	Miles
All-American	137
Lake Ontario-Hudson	128
St. Lawrence	25

Obstructions to navigation:

	Locks	*Bridges*
Lake Ontario-Hudson	20	54
St. Lawrence	9	8

The St. Lawrence route is nearer northern European ports by 625 miles than would be the Lake Ontario-Hudson route; but it is 1,550 miles further to New York and from 450 to 1,350 miles further to South Atlantic ports. These distances, however, are compensated for by better navigation in the St. Lawrence route.

12. The time required for construction has been estimated to be eight years, but it may be assumed that ten years will be the minimum period even though all international questions, legislation, administrative and financial problems can be rapidly overcome.

13. It is hardly necessary to discuss the military advantages of one route over the other, but they may be summed up in the words of the Chief of Engineers: "The military advantages of the proposed waterway across the State of New York are not sufficiently great enough to affect the consideration of a matter involving hundreds of millions of dollars. It will be noted that many points of both routes are so close to the border as to make them subject to possible destruction in case of war."

14. It is noted that the State of New York has a special interest in the development of power on the St. Lawrence route, but owing to the international character of the river, it will be necessary that the Federal Government assent to and negotiate power development questions from the American side.

15. It is feared by some eastern seaboard cities that in case the St. Lawrence route is constructed that they will lose some transfer and shipping business.

It may be stated that the total estimated tonnage for this route equals only 4 per cent of the present tonnage carried by the American Railway systems which now connect the Lakes with the Altantic Seaboard. It is equal to only 12 per cent of the shipments now moving through American sea ports. It is theoretically possible that the natural increase in traffic during the years of construction will increase to enough to completely offset any decrease that may come to American seaboard ports.

The conclusions of the Commission are:

1. The construction of the shipway from the Great Lakes to the sea is imperative.

2. The shipway should be constructed on the St. Lawrence route, provided suitable agreement can be made for its joint undertaking with the Dominion of Canada.

3. That the development of the power resources of the St. Lawrence should be undertaken by appropriate agencies.

4. That negotiations should be entered into with Canada in an endeavor to arrive in agreement upon all these subjects.

Engineering Aspects of the St. Lawrence Waterway

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THE purpose of the St. Lawrence Waterway is to afford an efficient water transportation route from the Great Lakes to the sea. Its engineering aspects deal primarily with the best means for creating such a highway for deep-draft shipping. But this is only part of the problem. The portion of the St. Lawrence that now remains a bar to such shipping has potential power resources whose eventual development will be an economic asset of far-reaching importance to the two nations concerned. The engineering problem is then to find the best means of co-ordinating improvement of the river for through deep-draft navigation with the immediate or ultimate development of its power resources.

From the point where it leaves Lake Ontario, the St. Lawrence lies along the boundary between the United States and Canada for a distance of 115 miles, with the Province of Ontario on the north and the State of New York on the south. The river then leaves the boundary and flows through the Province of Quebec to the Gulf of St. Lawrence. The port of Montreal lies 180 miles downstream from Lake Ontario.

From Montreal to the sea, the Dominion of Canada has already provided a channel thirty feet in depth at low water, which has made that city one of the great ports of the continent. A project is under way to enlarge this channel to a depth of 35 feet. The part of the river which bars Lake navigation from the sea, and ocean navigation from Lake Ontario, is therefore the 180-mile reach from that lake to Montreal. In this reach the river falls a total of some 225 feet over three successive series of rapids, lying between long stretches of deep, slow flowing water and expansions of the river course into lake reaches.

It is to be anticipated that hydro-electric generating machinery with a total installed capacity of some 5,000,000 horsepower will eventually develop the power economically utilizable from the large and uniform river flow through this section. More than half of this potential power lies on the portion of the river within the Province of Quebec.

The Great Lakes are of necessity an integral part of the waterway system of which the St. Lawrence Waterway would form a part. Each of the lakes has, it is needless to say, a depth adequate for vessels of any practicable draft, and the Straits of Mackinac, between lakes Michigan and Huron, also have ample depth for any navigation. The rivers connecting the other lakes are the limiting factor in determining the depth available for shipping on the lake system.

IMPROVEMENT OF INTERCONNECTING CHANNELS

The interconnecting Channels from Lake Superior through Lake Huron into Lake Erie have been improved by the United States Government by channel excavation, and by the construction of four parallel locks at St. Mary's Falls, at the outlet of Lake Superior, to afford a transportation route normally available for vessels of 20-foot draft. Canada has contributed a fifth lock at the St. Mary's Falls. The recent low water levels on the lakes, due to a cycle of low precipitation on their drainage basin, and to the diversion of water from Lake Michigan by the Chicago sanitary district, reduced the available draft at one time to as little as 18 feet. The draft that can be carried at the present time is about 19 feet. A report on the advisability and cost of a further improvement of the interlake channels has been directed by Congress and is in preparation.

The transportation route afforded by the channels between the lakes has given rise to a water commerce of great volume, moving upward of 100,000,000 tons of commerce per annum. Most of this commerce consists of bulk cargoes of iron ore, coal and grain, carried in a special type of vessel, longer and of greater capacity than the ordinary ocean cargo carrier, but of lighter draft to meet the limitations of the channel depth. With the loading and unloading machinery provided at the lake ports, the transportation of bulk freight has reached an unparalleled standard of efficiency.

Lake Ontario lies at an elevation 326 feet below Lake Erie. Navigation from Lake Erie to Lake Ontario passes through the Welland Canal, constructed and operated by the Dominion of Canada. The present Welland Canal affords a depth of 14 feet and overcomes the difference between the levels of the lakes by a series of 25 lift locks. Canada has now under construction a new Welland Ship Canal, generally paralleling the present canal. It is 25 miles in length, with but seven lift locks and a guard lock. The lock sills are set to afford a depth of 30 feet. The portions of the canal first excavated were given a depth of 25 feet; the later contracts provide for a depth of 27 feet.

From Lake Ontario to Montreal 14-foot navigation is now provided by side canals around the rapids in the St. Lawrence and by such channel excavation in the river as has been necessary for this draft.

The present Welland and St. Lawrence Canals form the connecting link, via Lake Ontario, between the general lake system of navigation and deep water at Montreal. This route is navigated by vessels of 14-foot draft, similar in design to the lake freighters, but of much smaller dimensions. They are relatively high-powered to meet the swifter currents of the St. Lawrence. The commerce via this route has been increasing rapidly in recent years, and is now somewhat in excess of 6,000,000 tons per annum.

In summary, navigation on the Great Lakes and the St. Lawrence now falls into three categories:

(a) Lake navigation, operating normally on 20-foot draft, on and between all the Lakes except Ontario.

(b) Canal navigation, 14-foot draft, between Lake Erie ports and Montreal via the Welland Canal, Lake Ontario and the St. Lawrence.

(c) Deep-sea navigation from Montreal to the ocean.

When the new Welland Ship Canal is opened, lake navigation will be extended to Lake Ontario, and will then be separated from deep-sea navigation only by the 180 odd miles of the St. Lawrence above Montreal. But if the St. Lawrence gateway was then opened, vessels exceeding 20 feet in draft would not be able to penetrate into the lakes beyond Lake Erie until the interlake channels are deepened.

IMPROVEMENT OF THE ST. LAWRENCE BETWEEN LAKE ONTARIO AND MONTREAL

Since it is in part a boundary stream, the improvement of the upper St. Lawrence is an international project.

Plans for the improvement of the river between Lake Ontario and Montreal were prepared in 1921 by a board composed of one engineer for the United States, and one for Canada. These plans were presented to the International Joint Commission, a permanent body created by treaty to deal with matters relating to the boundary waters between the two countries. The Joint Commission recommended that the two governments enter into a treaty arranging for the improvement of the river between Lake Ontario and Montreal. As it had received certain alternative plans for improving the international portion of the river for navigation and power, it further recommended that all plans presented be reviewed by an enlarged engineering board. In 1924 the two governments appointed such a board, known as the Joint Board of Engineers on the St. Lawrence Waterway.

The Joint Board of Engineers

The membership of the board was, for the United States, Major General Edgar Jadwin, Chief of Engineers, U. S. Army, Col. William Kelly, Corps of Engineers, U. S. Army and the writer; for Canada, Mr. Duncan W. McLachlan, of the Department of Railways and Canals, Dominion of Canada, Mr. Oliver O. Lefebvre, Chief Engineer, Quebec Streams Commission, and Brig. Gen. Charles Hamilton Mitchell, C.B., C.M.G., Dean of the College of Engineering of the University of Toronto. The report of this board was submitted on November 16, 1926, and appendices to the report, containing detailed discussions, plans and estimates, were filed in July, 1927. Under the instructions formulated by the two governments the report of the board included findings on certain collateral questions, such as the effect of diversions of water from the Great Lakes on the levels of the lakes and of the St. Lawrence. There will here be considered only that part of the report which deals with the St. Lawrence itself.

Report of the Board

The St. Lawrence leaves Lake Ontario as a deep, slow-flowing stream, split in places into many channels by the Thousand Islands and other island groups. At a distance of 67 miles from the lake the first rapids are met, and rapids and swift water continue through the remaining 48 miles of the international border. The most spectacular of these rapids are the Long Sault, near the foot of the reach. Leaving the border, the river expands into the quiet water of Lake St. Francis, which extends for about 27 miles. The river then drops through a succession of rapids, 15 miles in length, to Lake St. Louis. Lake St. Louis is 15 miles in length. From the lake the river passes in a turbulent course some 10 miles to Montreal Harbor. The famous Lachine Rapids lie in this last section.

The enormous reservoir of the Great Lakes equalizes the flow of the St. Lawrence and gives it an unparalleled uniformity of discharge. The river has no floods and no low water. Except where winter ice jams back up its levels, the range between high and low water marks is but a few feet. The minimum recorded monthly mean flow of 174,200 cubic feet per second in the upper St. Lawrence would be a flood on the Colorado; the maximum flow of 318,000 cubic feet per second would be low water on the lower Mississippi. In comparison the outflow from the Ohio ranges from some 30,000 cubic feet per second to some 1,500,000 cubic feet per second between low water and flood.

The large dependable discharge of

the St. Lawrence gives the river its great power possibilities. Moreover, because the flow is uniform, the river is not an eroding and silt-bearing stream. Its course has long since adjusted itself to the flow which it carries, and consequently it runs as a clear blue stream between stable banks. Surveys of the bed made 50 years ago are still reliable. There will be no problem in the maintenance of channels in the river after they are once excavated.

There are consequences of the uniformity of flow which are not so fortunate. Since the river does not erode its bed and banks it has not cut itself a deep valley. It flows generally but little below the natural surface of the ground. Since there are no floods the land has long been occupied and improved almost to the waters' edge. The construction of dams, to convert the rapid sections of the river into ponds, for the joint benefit of navigation and of power, will cause, therefore, large overflow damages. While the compensation for such damages is a relatively small item of cost in any plan of improvement, there is, on sentimental grounds, a demand that flooding be reduced to the minimum consistent with the public benefits resulting therefrom.

Again, since there are no marked low-water seasons on the St. Lawrence, the unwatering of the foundations of dams and other structures in the river becomes a major engineering undertaking and adds greatly to the cost of the works.

An essential feature in the preparation of plans for the improvement of the St. Lawrence is a reliable knowledge of the foundation conditions for the various structures. The Joint Board of Engineers supplemented the information previously available by some 450 borings, many of which were cored well into rock. In addition a special examination was made to verify the continuity of the rock under a proposed dam site at the Long Sault Rapids, where swift and broken water prevented the use of ordinary drilling methods. Shafts were sunk into rock on each shore, and from the bottom of these shafts horizontal diamond-drill borings were driven under the river bed. The results of all of these investigations show that suitable foundations are available for the various structures planned.

It is convenient to consider the St. Lawrence in five sections. Using the designations employed by the Joint Board of Engineers these are:

The Thousand Islands section, 67 miles in length, embracing the deep, slow-flowing part of the river from Lake Ontario to the first rapids.

The International Rapids section, 48 miles in length, embracing the rapids and swift water extending along the international boundary to Lake St. Francis.

The Lake St. Francis section, extending 26 miles to the end of deep water at the foot of that lake.

The Soulanges section, 18 miles in length, extending from deep water in Lake St. Francis to deep water at the head of Lake St. Louis.

The Lachine section, 23 miles in length, extending through Lake St. Louis and the rapids below them to Montreal harbor.

The improvement of the Thousand Islands section is solely a matter of removing certain dangerous rock reefs in the river, and of cutting back a few projecting points in the narrow parts of the channels between the islands, so as to afford safe and convenient navigation. The improvement of the Lake St. Francis section requires only the dredging of deep channels through shoals in the lake. Neither of these two sections offers any engineering complications. The engineering aspects of the proposal lie in the improvement of the three rapid sections—the International, the Soulange and the Lachine.

There are two general methods for carrying navigation past each of these sections. One is to construct a lateral canal, with locks, and the other is to convert the rapids into a navigable reach by the construction of a dam or dams with locks and short canals to carry navigation past the dams.

The enlargement of the existing 14-foot lateral canals may be summarily dismissed. These canals are so laid out as to require some 25 lockages in the transit between Lake Ontario and Montreal. The delay incident to such a number of lockages in an improved canal is inadmissable. Moreover, the existing canals carry an important traffic and must be kept in operation until a new waterway is opened. Their enlargement under traffic would be most difficult and expensive, if not impossible.

A new lateral canal requires, on the St. Lawrence, a less expenditure of funds than the construction of a dam in the river, but it affords a link in the navigation route through which vessels must move at slow speed, one which is subject to blockage should a vessel ground in the canal, and a route which cannot be enlarged readily to meet growing demands of traffic. The pool formed by a dam will afford open and unrestricted navigation, decidedly superior to that afforded by a canal. The concentrated fall at the dam will afford the means for developing power from the flow of the river, the value of which is an offset to the increased cost of pool navigation.

POWER DEVELOPMENT AND IMPROVEMENT OF NAVIGATION

While, therefore, the plans presented by the Joint Board of Engineers were prepared in accordance with the recognized principle that the interests of navigation on the St. Lawrence are paramount, yet the board found that the full observance of this principle does not interfere with the beneficial use of the flow of the river for power. On the contrary, the improvement of the rapid sections of the river for the joint benefit of navigation and power was found to afford, as a rule, much better navigation than could be secured by the improvement now economically justifiable in the interest of navigation alone.

The extent to which the development of power can be advantageously combined with the improvement of the river for navigation depends primarily on the rate at which power can be marketed. This is an economic question on which views may diverge quite widely. It is complicated by the economic policy entertained in Canada of restricting the export of power in order to stimulate the development of industries within her borders. The plans presented by the Joint Board provide for an initial power development in conjunction with navigation improvement which is based on conservative estimates of the rate at which power can be marketed under restrictions as to exportation. They provide however, for the eventual utilization of the complete power resources of the river.

A controlling limitation on the installation and operation of power plants on the St. Lawrence lies in the fact that any sensible hourly fluctuation in the volume of flow past Montreal is inadmissible from the standpoint of navigation in that port and in the channel from Montreal to the sea. Montreal is not a tidal port. The extreme low-water elevation of the water surface in the harbor is some 18 feet above sea level. The depths in the harbor are dependent upon the slope of the river between Montreal and Quebec, where the river finally reaches sea level. This slope is in turn dependent upon the volume of the discharge of the St. Lawrence and of the Ottawa, which join near Montreal. A fluctuation of 10 per cent in the discharge of the St. Lawrence produces a change of about one foot in the water level of Montreal Harbor. The depths in the harbor and in the channel to the sea have been won by the expenditure of large sums for dredging, and no diminution in depth through the operation of up-river power plants would be tolerated. These plants cannot be designed and operated to secure the maximum use of water by fluctuating the hourly flow to meet the fluctuating power demand.

POWER PLANTS AND WINTER DISCHARGE CAPACITY

The design and construction of hydro-electric machinery has reached such a stage that the design of power plants to develop the large quantities of power available in the St. Lawrence offers no new problems. The power plants must, however, operate both winter and summer if the power is to have any economic value, and the winter operation affords an unusual problem on the St. Lawrence. The critical feature is the maintenance of the winter discharge capacity of the river without excessive loss of head from ice gorging.

The rapid sections of the river now run open during the winter, for the currents are so swift that an ice sheet cannot form over them. From the time that the water in the river reaches the freezing point, in late December or early January, until the end of the winter, these exposed reaches are steadily making ice in the form of frazil and anchor ice. Frazil ice forms as minute crystals in the water, anchor ice as loose masses on the bed of the river, due to the loss of heat by radiation. The particles of frazil agglomerate in pans of soft, snow-like ice which float down the surface of the river; and the anchor ice when loosened by the heat of the sun rises to the surface and floats down in similar masses.

In the quiet water at the foot of each rapid section an ice cover forms early in the winter. The oncoming masses of slush ice pack against this until the sheet has progressed into currents so rapid that the slush is carried under the ice sheet, creating a hanging dam which gorges the river. The gorging causes a rise in the river surface which eventually permits the pack to extend upstream. The ice accumulations at the foot of the rapid reaches extend for miles at the end of winter, and raise the water level by from 10 to 30 feet.

In the present condition of the river, the ice packs at the foot of the rapid reaches never push their way so far upstream as to back up the water at the head of the reach. There is a free discharge at the head of each reach, and the flow down the river suffers only the minor retardation due to minor local ice obstruction.

The construction of a dam in any of the rapid reaches of the river will, in the general case, convert the downstream portion of the reach into a deep, slow-flowing pool, certain to freeze over early in the winter. The upper portion of the reach will necessarily remain open, because the water levels at the head of each of the three rapid sections cannot be raised sufficiently to prevent this condition without creating excessive flood damage. Any substantial raising of the water level at the head of the International Rapids section would flood out the cities on Lake Ontario; a raise of the water at the head of the Soulanges section would flood wide areas of the low-lying land that borders Lake St. Francis; and a substantial raise at the head of the Lachine section would flood the suburbs of Montreal.

ENLARGING CHANNEL TO PREVENT GORGES

The situation to be met when a dam is built in the St. Lawrence is, therefore, the prevention of an ice gorge at the head of the frozen pool formed by the dam. It can be met by enlarging the river channel in the upper portion of the rapid section until the currents are reduced to so low a velocity that the oncoming slush ice formed in the part of the river which remains open will not be carried under the ice sheet, but will consolidate on the surface, extending the sheet upstream. The plans for power development prepared by the Joint Board of Engineers are based on enlarging the upper reaches of the rapid section by excavation where necessary to ensure, with the discharges that must be maintained in winter, current velocities so low as to effect this condition, except through short distances at the extreme upper end of the reach, where the remaining area of open water could not produce enough ice to be of consequence.

The excavation required to accomplish this result runs into large figures. The wide and deep channels necessary for the purpose will afford superior navigation, and will reduce the river slopes to a minimum, affording a maximum concentration of fall for power production. Their cost can, however, be justified only by considerations of winter power operation.

It may be observed that the condition described is due to the great volume of winter flow of the St. Lawrence as compared with the capacity of its natural channels. On the ordinary northern river the rise required to adjust the slopes to its winter regimen is small in comparison with the rise during the spring floods, and does not have to be reckoned with in the development of power on the stream.

OTHER METHODS OF PREVENTING GORGES

Two other methods have been advanced for meeting the peculiar winter situation on the St. Lawrence. One of these is to build the dams at so low a height that the ponds will not freeze over. If, however, the water is raised by the dams sufficiently to make the river navigable for deep draft shipping, and to concentrate the fall for power development, the currents are necessarily reduced to a range sufficiently low to permit of the formation of an ice bridge across the stream under extreme weather conditions, but sufficiently high to convert this bridge into a hanging dam as soon as it has formed. The danger of the formation of an ice jam would always be present, and the consequences of its formation would be serious. Moreover, with the entire reach running open, the ice accumulating at the foot of the reach, as at present, would greatly reduce the head and the available power in winter.

A view has unfortunately gained wide credence that the formation of frazil ice is due to the agitation of the water in the rapids, and that if the river surface is raised sufficiently to produce a smooth flow, the amount of frazil will be greatly reduced, even if the river remain open in winter. It is an elementary principle of physics that the amount of ice formed is proportional to the amount of heat lost, and extensive measurements made by the Joint Board establish the fact that the winter heat losses from smooth flowing portions of the river are at substantially the same rate as from the portions broken by rapids.

An ice sheet over a ponded portion of

the river creates an insulating blanket which reduces the heat loss to a small figure; and the ice produced by this residual merely adds slightly to the thickness of the insulating blanket. Since there is no marked spring rise on the upper St. Lawrence, the spring break up of the ice sheet will occur quietly and will not give rise to the jams found on rivers in which the breakup is accompanied by a freshet discharge.

The studies made by the Joint Board show conclusively that the problem of winter power operation on the St. Lawrence can be best met by works designed to create an ice cover over the river.

A second method that has been proposed for meeting the peculiar winter conditions on the St. Lawrence is to construct the power dam to such height as will utilize a part only of the full available fall in the reach, reserving the remaining available fall, by means of a control structure at the head of the reach, to overcome the retardation created by winter gorging. An inherent difficulty with such a proposal is that it aggravates the condition that it is intended to remedy, because with the pool at a lower level, the length of the swifter running open river will necessarily be increased. Unless an ample margin of head is reserved, severe weather conditions might lead to its exhaustion before the end of winter. Works designed on this principle do not conserve the full value of the natural power resources of the river, and the cost of the control works is not substantially less than the cost of the channel enlargement designed to prevent the condition that the control works are intended to remedy.

The plans proposed by the Joint Board of Engineers are based on the foregoing considerations of the general problems involved.

PLANS FOR THE INTERNATIONAL RAPIDS SECTION

In the International Rapids section, extending 48 miles along the international border, the river has a total fall of 92 feet, a large part of which is concentrated in the Long Sault Rapids, near the foot of the reach. In this section the ponding of the river by a dam or dams, for the joint benefit of navigation and power, unquestionably affords the best method of development. The length of the section is such that a side canal for navigation would be extremely costly and would impose an unnecessary hindrance to shipping. A market exists in the United States for the prompt absorption of all the power attributed to it from the development. While the market for power in the Province of Ontario is less extensive, there is a present demand for at least some of the power that would be generated.

Two plans for improvement were prepared by the Board, both of which were designed to open this portion of the river to deep-draft navigation, to assure the fullest practicable utilization of the power resources of the river, and to secure dependable winter power operation. One of these plans proposed to convert the entire section into a single navigable pool by means of a single high dam and power houses, to be constructed at the foot of the reach, at Barnhart Island. This is designated the single-stage development. The second plan was for a two-stage development through the creation of an upper and a lower pool, the upper pool being formed by a dam and power house about midway through the reach, at Ogden Island, and the lower pool by a dam and power houses at Barnhart Island that would have 18 feet less height than in the single-stage development.

With the single-stage development, navigation would enter the pool through a free channel from the upper river, and would pass from the lower end of the pool through a short canal on the American shore, with two locks, into a channel leading to Lake St. Francis. With the two-stage development navigation would similarly enter the upper pool through a free channel, pass from the upper to the lower pool through a lock at the Ogden Island Dam, and from the lower pool through a canal with two locks to Lake St. Francis as in the single-stage plan. The two-stage development would therefore require one more lock than the single stage.

The computed head at the power houses in the single-stage development is 85 feet. It is expected that the increased resistance of the ice-covered pool, and of ice obstruction in the tail races, will reduce the head to about 75 feet in winter. The power houses are to be built to provide for the eventual installation of hydro-electric generating machinery with a capacity of 2,326,000 horsepower. This will utilize the mean discharge of the river.

With the two-stage plan the computed head at the upper power house at Ogden Island is 17 feet in summer and 12 feet in winter, at the lower power houses 67 feet in summer and 63 feet in winter. They are to be constructed for the eventual installation of 406,400 horsepower at the upper power house and 1,808,600 at the lower, a total of 2,215,000 horsepower.

The plans for the single-stage development include the provision of controlling gates at the head of the reach at Galop Island with a free navigable pass 450 feet in width. These gates will normally remain open.

The amount of channel enlargement required to assure satisfactory winter operation cannot be predicted in advance with certainty. It is proposed to execute initially only such enlargement as is necessary to insure satisfactory navigation conditions and to prosecute this enlargement after the pool has been created, when dredging can be done more advantageously, until satisfactory winter operation is secured. The control of the head through the section afforded by the control gates at the Galop will afford a means for insuring the winter discharge capacity of the river during this period.

The estimated cost of the single-stage development, including the eventual enlargement of the channels to the extent foreseen as necessary to assure winter operation, and the eventual installation of hydroelectric generating machinery to the full power-house capacity is $235,000,000. This includes compensation for 22,000 acres of land that would be inundated by the execution of the project and for all damages related thereto. The estimated cost of the two-stage development, similarly complete, is $264,500,000. The area inundated would be 12,000 acres.

The United States Section of the Joint Board recommended the single-stage development as affording better navigation through the elimination of one lock, and slightly more power, at a cost of $29,600,000 less than the cost of a two-stage development.

The Canadian Section of the board recommended the two-stage development on the ground that it can be carried out in two parts, so that power from the upper development can be developed and marketed before the whole of the project is completed. It believed that for this reason the overall cost, including interest charges, will not be as greatly in excess of the single-stage development as appears from the comparative costs without interest charges. It believed that control over the flow of the river would be better assured. Flowage of land would be reduced as has been indicated.

Studies made by the Canadian Section subsequent to the submission of the report have lead it to prefer a two-stage project with the upper dam about 7 miles farther downstream, at Crysler Island. The lower pool would be at an elevation 7 feet below that proposed in the former project, affording a much more favorable head at the upper power house. The estimated cost of this modified two-stage project is $269,355,000, or about $5,000,000 in excess of the project with the upper dam at Ogden Island, and flooding damages are somewhat increased. The number of locks remains the same. Its advantage lies in the better power operating conditions afforded by the increased head at the power house of the upper dam.

It may be observed that the construction of both dams of the two-stage development, with connected powerhouse substructures, is necessary before navigation can be opened through the reach.

In this section the paramount interest of navigation is overshadowed by the large expenditures required for power development. The cost of the locks and their approaches and other works requisite only for navigation is but about $25,000,000 with the single-stage development, or about $33,000,000 with the two-stage. The remaining sums are required for power development whether or not navigation is provided. It is to be anticipated, therefore, that the arrangements made for financing the power development will determine the choice of the plan eventually selected.

THE SOULANGES SECTION

In the Soulanges section, extending 18 miles from Lake St. Francis to Lake St. Louis, there is a total fall of about 83 feet. At the Cedars Rapids, midway in the section, an existing and quite modern power plant diverts about one-third of the river flow and develops power with about 32-foot head.

While the probable lack of market indicates that the immediate complete development of the power in this section in conjunction with navigation improvements would not be economically justifiable, the Joint Board of Engineers found it to be practicable and advantageous to combine the improvement for navigation with the development of power on a progressive program of construction of power plants, only the first part of the power development being undertaken in conjunction with the works required to carry navigation through the section.

This plan provides for the construction of a dam and power houses at the head of the Cedar Rapids, which would create a navigable pool in the upper part of the section, and would afford a head of 22 feet. Navigation would enter this pool from Lake St. Francis through a canal, 3 miles in length with one low lift lock, and would pass from the pool to Lake St. Louis through a second canal, 5 miles in length, with two lift locks.

The estimated cost of this initial development, including the development of 382,000 horsepower at the power houses, is $104,000,000. The eventual development of the remaining available power, in part by a head-race canal to the escarpment at Lake St. Louis and in part by a second dam and power house at the foot of the section, is $101,000,000. The total installed hydroelectric generating machinery in the eventual complete development would have a capacity of about 2,000,000 horsepower.

A comprehensive scheme for the

immediate development of the entire power resources of the river, and the utilization of the entire river course for navigation, by the construction of two dams which would convert the river into two navigable pools, was found to cost $10,000,000 less than the eventual cost of the successive power development with the plans recommended. It was regarded as meriting serious consideration if a market for the large amount of power can be found within a reasonable period.

The Joint Board of Engineers united in the view that the plan first outlined better provides for the present and future development of the waterway than any scheme for navigation alone, and is therefore the desirable plan, if arrangements are made whereby power interests bear a fair proportion of the initial expenditure required.

If it be found impossible to arrange for such coöperation in meeting the initial cost, a majority of the Canadian Section of the Board favored the construction of a lateral canal for navigation on the south side of the river, at an estimated cost of $33,640,000. It would be about 15 miles in length from shore to shore. A canal can be built in this location at the least cost, but no part of the canal can be subsequently incorporated in a development of the river channels for navigation. The United States Section submitted the view that a route designed to serve so large a territory will demand eventually the freer navigation of the open river. It believed, therefore, that even if arrangements cannot be made for the participation of power development in the initial development, it would be better to proceed on the plans laid out for this development, limiting the construction of the power houses to the substructures. The cost, when so curtailed, would be $78,515,000. As an alternative the United States Section suggested a canal on the north side of the river, at a cost of $40,378,000, most of which could be utilized in connection with a subsequent development of the river channel.

PLANS FOR THE LACHINE SECTION

The remaining section for consideration is the Lachine section, which includes Lake St. Louis and the 10 miles of rapids, swift water and shoals between that lake and Montreal Harbor. In this section, the first 11 miles through Lake St. Louis are in deep water, the remaining 4 miles are through the shoal water at its foot. The total fall through the section is 48 feet, of which 24 feet is the fall through the Lachine Rapids.

The winter rise in and above Montreal Harbor, due to the accumulation of ice, reduces the total fall to about 30 feet.

The Joint Board of Engineers found that in this section it was not feasible to utilize any part river channel below Lake St. Louis for navigation without an excessive amount of costly excavation, on account of the high current velocities in this contracted section of the river even when raised to its highest practicable level. It found, therefore, that a side canal affords the most suitable route for navigation between Lake St. Louis and Montreal Harbor.

The route selected for the side canal follows close to the river bank in order that it will not interfere with the future growth of the city of Montreal and will not introduce the difficult problem inherent to the crossing of land and water traffic, with the consequent inconvenience and delay to both. It has three lift locks and a guard gate.

The city of Montreal lies on an island at the confluence of the St. Lawrence and the Ottawa. A part of the discharge of the Ottawa is delivered into

Lake St. Louis above the city, and a part flows north of the city, joining the St. Lawrence at the foot of the island on which the city lies. On account of the widely varying flow of the Ottawa, there is a range of about 8 feet in the levels of Lake St. Louis. In order to reduce the excavation of the upper level of the navigation canal and of the channel required through the long shoal at the foot of the lake, the plans include the construction of a control dam in the river below the lake, by which the levels of the lake can be held up during the navigation season. Flood discharges will be passed through the dam. The plans provide for a dam of the rolling shutter type, which will be entirely opened in winter, so that the winter regimen of the river will not be changed. Supplemental control works are required in the other outlets of the Ottawa to preserve the present proportional flow past Montreal during the low-water season. The cost of the entire system of control works is about $2,000,000 in excess of the saving in excavation costs which they effect, but these works will reduce the cost of any future development of power at the Lachine Rapids, besides being of benefit to local navigation on the lake. The entire cost of the improvements proposed in this section is $53,000,000. They are coördinated with the future development of the full power resources of the section.

The plans that have been described for the improvement of the various sections of the river provide for channels which can eventually be enlarged to a depth of 30 feet, the lock sills and other fixed structures being designed for that depth. The estimates that have been given are for an initial excavation of the channels to a minimum depth of 25 feet, which will be suitable for navigation by vessels not exceeding 23 feet salt-water draft. The total estimated cost of the entire improvement of the St. Lawrence between Lake Ontario and Montreal, including the installation of hydroelectric power generating machinery to the full capacity of the power houses of the power developments initially proposed, with the channels initially excavated to a depth of 25 feet, is from approximately $394,000,000 to $428,000,000 depending upon the form of improvement adopted in the International Rapids section. This includes the cost of power works with an installed capacity of from 2,730,000 horsepower to 2,619,000 horsepower, the value of which can be conservatively placed at between $250,000,000 and $300,000,000.

The added cost of providing initially channels 27 feet in depth is estimated at $5,800,000. The reduction in cost if channels 23 feet in depth are initially provided is estimated at $5,300,000. It may be observed that the broad economic question of the depth that should be provided initially rests on the cost of the requisite deepening of the interconnecting channels and the harbors on the Great Lakes to derive the benefit from the waterway.

It is to be borne in mind that the draft of a vessel must be less than the channel depths. Channels 23 feet in depth are suitable for the navigation of vessels not to exceed 21 feet salt-water draft; channels of 25 feet depth for vessels not exceeding 23 feet salt-water draft, and channels 27 feet depth for vessels of 25 feet salt-water draft. For vessels of the size of those that would use the proposed St. Lawrence Waterway, the fresh-water draft exceeds the salt-water draft by from 6 to 7 inches.

The plans which have been described provide for a navigation route from Lake Ontario to Montreal Harbor with a total not to exceed 25 miles of restricted canal navigation and with not more than nine locks. It will be crossed by but eight bridges. The capacity of the waterway is estimated at 24,000,000 tons per annum.

A commission headed by the Hon. Herbert Hoover, which was appointed by the President of the United States to advise on the development of a shipway from the Great Lakes to the sea, received for the United States the report of the Joint Board of Engineers. Their conclusions are as follows:

First. The construction of the shipway from the Great Lakes to the sea is imperative both for the relief and for the future development of a vast area in the interior of the continent.

Second. The shipway should be constructed on the St. Lawrence route, provided suitable agreement can be made for its joint undertaking with the Dominion of Canada.

Third. That the development of the power resources of the St. Lawrence should be undertaken by appropriate agencies.

Fourth. That negotiations should be entered into with Canada in an endeavor to arrive at agreement upon all these subjects. In such negotiations the United States should recognize the proper relations of New York to the power development in the International Section.

The report of the Joint Board of Engineers advances the consideration of the proposal to the stage at which it becomes a problem of statesmanship. There can be no question of the practicability of the proposal from an engineering standpoint after the international, financial and economic questions in connection with the work have been determined upon.

What the St. Lawrence Waterway Means to the United States

By W. L. HARDING

President, Great Lakes-St. Lawrence Tidewater Association

THE demand throughout the west for a ship channel outlet from the Great Lakes to the Atlantic Ocean, by way of the St. Lawrence, rests upon the need of that region for more direct and cheaper connection with the markets of the world, and also upon the physical make-up of the North American continent, which lends itself, by reason of the location, depth, and breadth of the Great Lakes and St. Lawrence River, to such a connection —a connection that would give to the North American continent, a fourth ocean, its shores reaching to the borders of the harvest fields of the Middle West, now removed a thousand miles and more from contact with the sea.

On no other continent has civilization entrenched itself at any considerable distance from the ocean. On this continent alone it has done so under conditions that do not assure its continuance, unless the transportation handicap that distance from the sea always and everywhere involves be removed.

The North American mid-continent was claimed for civilization under peculiar conditions. The movement from the Atlantic over the mountains and into the plains beyond began before the days of the steamboat or of the railroad, and when the tools of industry and agriculture were for the most part as crude as they were in the days of Caesar. Not even the plow was yet an efficient tool, and the grain drill, the binder, the threshing machine were all unknown. The agriculture of western European lands was settled in its ways, and that of our now great competitors—Argentina, Australia, Russia —was not a factor in world trade— in fact, did not cast a shadow over the future.

We invented the steamboat, we adapted the railroad, we improved the plow, we invented the reaper, the grain drill, the threshing machine and the modern binder, and we developed, ahead of any other nation, all of these things and put them to our purpose of subduing a continent.

By the most ingenious system of bonuses ever known to history, we invited the pioneers of three generations to put the lands of the interior under cultivation—lands that, for the larger part were level, treeless and rich and that made our quick results of large acreage under the plow and large production possible.

We financed our wars out of these lands. We held out to our farmers as a reward for their labor, not a fair return in cash for the crops harvested, but an increasing equity in the lands themselves, as the country might settle up and the value of the lands might increase.

The network of our railroads spread over the interior and on to the Pacific. The iron ores of Minnesota, the copper of Michigan and of Montana, the output of the smelters in the Rockies was added to the golden harvest of the farmers. The inland ocean of the Great Lakes became busy with a water-borne commerce that told of the rising greatness of Buffalo, Toledo, Cleveland, Detroit, Milwaukee, Duluth-Superior, Chicago and other thriving harbors.

The great cities of the prairies were called into being. The packing business moved westward from Cincinnati, and the day of the open ranges began. The prairie states of the Middle West settled into their agricultural stride.

Then our factories carried the plow, the binder, the thresher to other and new lands, agriculturally speaking—to the Argentine, to Australia, to Russia—all lying close to the sea, all able to ship from the farm to the market in Europe for less money than we can possibly hope to—unless a way can be found to move our farm lands closer to the ocean.

Our three great advantages—lands cheaply acquired, easily tilled, and stored with a wealth of bankable fertility—made possible the civilization that is now ours in the Middle West; these, coupled with the fact that we had no large or active competition in the market places of the world.

We now have that competition. It is here to stay. It will increase, rather than diminish, with the passing of time. New areas, outside of this continent, and fit for agriculture, will develop and become competitors of ours, with whom we must in all the future years do a competitive business.

For the major portion of the things the Middle West produces, the world's market place is Europe. Europe is where the consumers are—Western Europe, the Baltic, the Mediterranean. The people of the Atlantic Coast cities are fed in good part by the farmers of the east—by the farmers westward to the Mississippi. And the farmers of the trans-Mississippi region are thrown back upon the European market with their surplus—with the surplus which we as a nation need to continue and will continue to produce in order that at all times we may have plenty for ourselves.

EXCEEDS DOMESTIC NEEDS

The transportation-handicapped region of the United States is neither small in producing power nor is its production going to cease. This region possesses 63 per cent of the dairy cows, 55 per cent of other cattle, 75 per cent of the hogs, 76 per cent of the sheep, 61 per cent of the horses and 63 per cent of the total live stock value of the United States, as estimated by the United States Department of Agriculture. Of the edible crops—that is, excluding flax, tobacco and cotton—the transportation marooned area produces approximately 60 per cent. And except for the South, when the area of farm acreage expansion is considerable, the marooned area under discussion holds the reserve high grade agricultural lands of the nation.

Taking the national resources that are non-agricultural, the transportation-locked area leads in hydro-electric power with approximately 50 per cent of the potential supply of the United States. This region contains our future supply of coal and of petroleum; here are our copper and lead and iron supplies both of today and for the years to come. These unused and tangible resources point to expansion in the future, conditioned only upon the access of the Middle West to the markets of the world on an even footing.

The point, without being too dry-as-dust statistical, is that the transportation-handicapped area within the United States is producing now, and can and will expand its production in the future well beyond any present or near future home consumption requirements.

CONTINUING INTERNATIONAL TRADE

According to the United States official figures for 1922, the average per capita wealth of the marooned area is $3553. The average per capita wealth of the entire United States was, for that year, $2918. This can mean nothing else than that, both in producing and consuming power, the area in question, with its 45,000,000 people, carries its share of the load of foreign commerce, both going and coming. That commerce amounted, in 1924, in goods sent and received overseas, to 80,514,000 long tons, of which the marooned area's equitable portion, produced or consumed, would be 40 per cent, or 32,000,000 tons.

That, however, is not the yardstick by which to measure the need of the American interior for better transportation. That estimate is arrived at by detailed studies of all lines of production. It is worth while to consider whether any people engaged in the wholesale production of crude and bulky materials such as grain, foods, ores and the like will ever cease very largely to produce those things, or other things comparable in tonnage.

For example, contrary to popular opinion, the percentage and the volume of wheat exports from the United States have not decreased with the passing years. From 1866 forward the largest per cent of any wheat crop shipped abroad was during the period 1876–1906, during which time we exported an annual average of 30 per cent of our crop. In 1922 we exported 25.6 per cent; in 1923 we shipped out 19.9 per cent and in 1924 our shipments reached 28.8 per cent. The bushel figures are even more striking, showing that right now, in these post war years, the American farmer is maintaining his production and his exports of wheat well above the levels of the pre-war years. Today the wheat acreage of the nation is again expanding. And if the farmer of a coming generation chooses to abandon wheat it will be in order that he may produce other bulky foods, that, like wheat, create tonnage and invite tonnage in return. And it will be for the obvious reason that the production of these other things will be more profitable to him, and will make of him a more important trade-load factor. As an example the farmer has ceased to export flax. What is the result? The nation imports flax—ships it inland to the linseed mills situated on Lake Erie and at Minneapolis. Little, if any, tonnage of flax movement has been lost, and the erstwhile flax farmer is growing other tonnage and making crops more profitable. The result is a net gain in tonnage. The idea of a vanishing export tonnage from the interior and to the interior of the continent is a myth.

ENHANCES NATIONAL ECONOMY

Of the 80,000,000 long tons comprising the total 1924 overseas commerce of the United States 43,000,000 moved out of or into the ports of the North Atlantic, 23,000,000 by way of the Gulf of Mexico, 12,000,000 out of and into our Pacific harbors, and the balance from the South Atlantic ports. In addition to this there was a Great Lakes total movement to and from Canada amounting to 15,500,000 tons. These figures will indicate, to some extent at least, the general directions taken by our commerce in seeking outlet to the sea. They parallel the rail and water movements throughout the country, and they cast a side light upon the fact, already mentioned, that Europe is by far our largest customer, especially for those products that are essentially mid-western in origin, such as grain, food products, and the fabricated products of iron, copper, etc.

The transportation handicap which this interior commerce is under when moving into world trade is measurable.

The difference between the existing rate by rail to the Great Lakes, thence by water to Buffalo, by rail from Buffalo to New York, and from New York by ship to Liverpool, and a fair transportation charge for same cargo moving by rail to the Great Lakes and by water direct to Liverpool is set, by Alfred H. Ritter, Transportation Specialist of the War Department at a minimum of $4.00 per ton in favor of the St. Lawrence route, assuming that ships of ocean draft could ascend into the upper Great Lakes with, and for cargo.

The report of the President's Advisory Committee, the St. Lawrence Commission of the United States of which the Hon. Herbert Hoover is chairman, estimates that at present there is available for movement over this waterway 23,000,000 tons of cargo. This Commission states that,

> It has been estimated that the values in a single year to the farmers alone would equal the capital cost ($123,500,000) of the waterway.

But in considering the question of possible tonnage a larger aspect of the problem should not be forgotten. A major transportation route not only fixes the rates chargeable by secondary routes, but it also fixes basic price levels throughout the area of its influence. Today the price of wheat in the mid-continent of North America is determined by the world market price, *less* the cost of transportation. Cut the transportation charge and you do not benefit the buyer. His requirements and market supply remain as before—the saving reflects back to the shipper, and the farm price levels advance on *all* wheat sold, both for local consumption and for export.

An illustration may serve to make this point clear.

A farmer sells grain to a local miller. The price he receives will be based on the local price for grain, which in turn is based on Liverpool, minus the total freight, from his station to that terminal market. It is obvious that, in this instance, the farmer, whose grain is ground into flour at the local mill, *actually pays freight on his wheat to Liverpool.* And whatever lowering of the freight rate may be obtained by opening the Great Lakes to Ocean commerce, will benefit that farmer to the same extent as it will benefit the man whose wheat crosses the ocean.

This principle of local price control through the establishment of low cost transportation to the ultimate market holds true for barley and for corn and lard, and for bacon and for lumber and copper and wooden ware and steel safes and machinery and clothing, for automobiles and for all the multitude of things produced or used by and in the mid-region. Today the Great Lakes-Ocean trunk line that runs via Buffalo and New York sets the price levels. Open a wider, better path—an adequate path—and every business and not the farmer alone, must and will benefit thereby.

The foregoing estimates of tonnage and of saving thereon, using Alfred H. Ritter's figures, indicate an annual direct overcharge on actual movement out of and into the freight-handicapped mid-region amounting annually to $120,000,000. Nor does this take into account the unseen charge, by way of depressed price levels, on things produced but not exported. One hundred and twenty million dollars is interest, at 4 per cent, on $3,000,000,000. This figure is arrived at merely as suggesting that a reasonable expenditure of public money so used so to turn this capital value into productive channels may be justified on broad grounds of national economy.

By their official action twenty-two

states have severally and jointly approved the opening of the St. Lawrence barriers between the Great Lakes and the Atlantic. These states comprise what is known as the Great Lakes-St. Lawrence Tidewater Association. It should be clearly understood that the purpose of these states is not to reach any one point on the Atlantic, but rather to reach the ocean itself. They are not looking for a way to New York, only as and insofar as New York is one of the port cities of the world. The marooned interior comprising these tates is looking for a trade road to *all* he world—not for a detour, nor for a alf-way depot. It seeks a trunk line ut of the Great Lakes and onto the igh seas. Once there it can steer its ourse to the most desirable market.

A glance at a globe of the world will make clear the reasons for this deterination. From the dawn of history ntil today, sea routes have controlled he world's trade. They still do. hey always will. The reason is imple. Water transportation is far heaper than transportation by land. oday, steamship against freight car, he cost is about one to ten. The cost f one mile of land transportation buys n miles of ocean transportation.

And within the memory of men we ave remade the map of the world. Ve have cut the isthmus of Suez and rought India, China, Japan, Australia e eastern coast of Africa thousands f sea miles closer than ever before to e doorstep of our principal buyer—urope. We have cut the isthmus of anama and once more we have floated e continents closer together. By uilding the Panama Canal we have ut Calgary and Seattle closer to urope by way of the Pacific and the aribbean than they are by way of e direct rising sun and Atlantic road. nd of still deeper, more direct and tal concern to the interior of this continent, the building of the Panama performed the miracle of bringing San Francisco and New York—the Pacific coast and the Atlantic—closer to each other than either city or either coast is to any inland point five hundred miles removed from the ocean. This has landlocked the interior of the North American continent. While our seacoasts move forward under the stimulus of lowered sea rates and active participation in world trade, the interior finds its transportation rates to and from the sea advanced, its competitors in other lands able, by reason of short land haul, to meet world conditions and prices that deny to the mid-section of North America its place in the world's markets—unless we finish the job of world rebuilding along lines obviously pointed out to us by nature.

The world is round. The eastern coast of the United States points not toward the North Pole, but toward Europe. So do the Great Lakes and St. Lawrence River. For two thousand miles this natural highway parallels the Atlantic coast. The Great Lakes, carrying a commerce equal to more than one-fourth the ton mileage of all the railroads within the United States, are open to ships of ordinary ocean draft and tonnage from Duluth and Chicago to Buffalo. Their channels are wide, their harbors ample, they are, in fact, an ocean extending a thousand miles along our northern border, linking the coal fields and the iron mines, linking the corn belt and the grain fields with the industrial East. Across the Niagara isthmus, the Welland Ship Canal is nearly ready to take the largest Great Lakes ships and let them down into Lake Ontario, where from the foot of the Welland Ship Canal, now nearing completion, to Ogdensburg on the St. Lawrence is deep water. From Montreal, the second largest port of the Atlantic seaboard, to Liverpool and to all western and southern Europe the sea lanes are wide open. Five thousand miles of sea channel extend from Duluth and Chicago to Liverpool and points beyond, and all accounted for as deep, wide, free navigation adapted to ocean-going shipping, except twenty-five miles. That is the picture the ship captains see. That is the picture the Joint Board of Army Engineers of two nations paints for us. That is what the mid-continent has to start with when it demands a sea-road to Europe.

The engineering problems involved do not properly belong to this discussion. It may suffice to say that, not without thought, not without full examination into any and all routes, and with a complete knowledge of what the engineers of both nations had already done, was the choice of the marooned interior fixed upon the St. Lawrence as the only practical route to the sea.

Not only was the fact that the St. Lawrence route is a "going concern" taken into account, but also the fact that the numerous surveys of that route and other routes plainly indicated its preferability to the continental interior for the purpose of establishing an unrestricted thoroughfare to the world bordering upon the high seas. The Associated States rest their case as to the engineering feasibility of the route chosen upon the decision of the Joint American-Canadian Board of Engineers, in two reports.

The basic engineering facts are well known. Time required, lift, restriction of traffic, cost—all these things more closely computed by the Joint Board of Canadian and American Engineers that surveyed the St. Lawrence route in 1920–21, and again in 1925–26.

There is no alternative route. There is no other sea road to and from the industrial and agricultural empire westward of the Appalachians. Rivers that carry us to the sea, canals that climb the hills—these may serve a useful purpose in the quickening of our transportation circulation, but they are, at their ultimate best, but highways leading down to the ocean. And when one takes to a highway he will, if he is wise, choose one that leads toward his destination. The Great Lakes are in themselves an ocean. The St. Lawrence is a strait. Across the seas that send their tides a thousand miles up its broad bosom is the great market place of the world. There the mid-continent buys and there the mid-continent sells, and between Duluth and Liverpool, between Chicago and the Baltic, between Detroit, and Marseilles lie today two great barriers—one of rock, that can be measured, drilled, blasted until the waters run deep and free, until the ships can go out and in.

The other barrier is that of misunderstanding as to need and purpose. And it, too, bearing in mind the history of this America of ours, is removable.

The Economic and National Significance of Connecting the Great Lakes with the Sea by the St. Lawrence Route

By Hon. I. L. Lenroot
United States Senator, Wisconsin

I HAVE been asked to discuss the economic and national significance of connecting the Great Lakes with the sea, by the St. Lawrence route.

Speaking first of its national significance, it is demanded by 40,000,000 of our people in the West, more than one-third of our population, because of the economic benefits that will result in bringing the Atlantic Ocean to the heart of the continent, and making ocean ports of all of our cities upon the Great Lakes. It is also demanded by a large majority of the people of our New England States because of transportation benefits and the cheap power that will be developed for their use, which will remove one of the most serious handicaps to the continued existence of their industries.

The history of the idea of connecting the Great Lakes with the sea is most interesting. It has been a dream of many years, almost since the Republic was founded, and its history is not so dissimilar to the history of the Panama Canal. It may not be generally known that the first project for connecting the Great Lakes with the sea was inaugurated by George Washington. In 1792 he obtained the passage of an Act of Incorporation by the Legislature of the State of New York for the construction of a waterway between the Hudson River and Lake Erie by a system of canals and slack water and lake navigation by way of the Mohawk River, Oneida Lake and River, and Oswego Lake and Ontario. Of course, Washington little dreamed of the leviathans of the deep that we have in our day. As we all know, canals have been constructed. We have today the Erie Canal, but it does not permit the passage of ocean-going vessels into the Lakes, and although the State of New York has expended more than $200,000,000 upon this project, it has proved to be a colossal failure, and Government boards, one after another, engineering and otherwise, have reported that it is not practical, except at a prohibitive cost, to construct a canal between the Great Lakes and the Hudson River, that will admit ocean-going vessels to the Lakes.

Twenty-two states have joined in an association, known as the Great Lakes-St. Lawrence Tidewater Association, to promote the St. Lawrence route, the governors of each being *ex-officio* a member of the Council of States directing the activities of the Association. The mere recital of the names of the states indicates the national character of the organization. They are Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, Colorado, Wyoming, Montana, Idaho, Utah, Washington, Oregon, South Carolina, West Virginia, and Kentucky. Its Executive Director is Charles P. Craig, of Duluth, with headquarters at Washington.

The International Joint Commission, a permanent official body consisting of three persons appointed by the President of the United States, and three persons appointed by the Government of the Dominion of Canada, in 1922 made a report upon this subject unanimously recommending the St. Lawrence route. They said:

> The conclusion is obvious that if countries that had for the most part to import their raw materials from abroad were able to build up a great foreign trade because of their ready access to the sea, the region economically tributary to the Great Lakes, with its limitless resources, its raw materials within easy reach, its facilities for industrial expansion, can hardly fail to become an even greater factor in the world's markets than it is today, if given a practical and efficient water route to the sea.

On March 14, 1924, President Coolidge appointed a commission with Hon. Herbert Hoover, Secretary of Commerce, as chairman, to make a further study of the subject. On December 27, 1926, it made its report unanimously recommending the St. Lawrence route. I quote from its report:

> The construction of a shipway of sufficient depth to admit ocean-going shipping from the Atlantic to the Great Lakes will lessen the economic handicaps of adverse transportation costs of a vast area in the interior of the continent. Within the United States it embraces all or large portions of the states of Ohio, Indiana, Kentucky, Illinois, Iowa, Missouri, Kansas, Nebraska, North and South Dakota, Montana, Wisconsin, Minnesota, Michigan, Pennsylvania and New York. It includes a large part of Canada. Within this area there are more than 40,000,000 inhabitants who gain their livelihood from its basic industries. It produces a vast surplus both from agriculture and manufactures, much of which demands long transportation. . . . It has been estimated that the values in a single year to the farmers alone would equal the capital cost of the waterway. . . .
>
> The interior states which are affected by this situation have not been neglectful of the benefits to be derived by the bringing to them of ship transportation to the sea. Eighteen of them have associated together by acts of their legislatures, under the name of the Great Lakes-St. Lawrence Tidewater Association. They represent nearly two-fifths of our population. They have made their own independent investigation and have concluded and declared that the opening of the Great Lakes to ocean-going vessels through the St. Lawrence is a major public necessity in the economic interest of their communities.

The Commission further stated that:

> The construction of the shipway from the Great Lakes to the sea is imperative both for the relief and for the future development of a vast area in the interior of the continent.
>
> The shipway should be constructed on the St. Lawrence route, provided suitable agreement can be made for its joint undertaking with the Dominion of Canada.

Of its benefit to the entire nation, the Commission said:

> In the wider view, the increased prosperity of the mid-continent, the relief of many of their present economic difficulties, and development of huge water power for stimulation of industry and commerce in New England shall add to the prosperity of the country as a whole and thereby benefit every citizen and every city.

A New England committee, consisting of prominent citizens of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut, of which Col. Charles R. Gow of Boston is chairman, has made a study of the subject, and a few months ago made a report unanimously recommending the St. Lawrence route. I quote from its conclusions:

> It is our belief that a reduction in transportation costs is the primary requisite of the central section of the country today and that its accomplishment would afford more real relief to the farming and other elements of that community than would any of the proposals which so far have been advanced for the proposed amelioration of the farmers' condition.

Every impartial body that has studied this subject has recommended the St. Lawrence Waterway as a great national undertaking of great national benefit. The only opposition comes from the State of New York, and that state is not unanimous in its opposition. A large part of northern New York is enthusiastically in favor of the project. The opposition is selfish, fearing that the commerce of the cities of New York and Buffalo will be injured by the project. It is hard to believe that the intelligent patriotic citizens of that great state when they fully understand the question will be in favor of compelling the distressed farmers of the West to pay a wholly unnecessary toll to the cities of New York and Buffalo solely for their benefit.

THE ECONOMIC SIGNIFICANCE OF THE ST. LAWRENCE ROUTE

That our farmers of the West have ever since 1920 been in great financial distress we all know. That they have for years been demanding from the Congress relief from their economic condition we also know. In their dire need for relief many of them have become the innocent victims of designing politicians who make impossible promises to them, and propose remedies that cannot stand either the test of constitutional authority or common sense.

Because these things are so should not cause us to fail to realize that our farmers are suffering under a great economic handicap, and because most of the plans that are proposed for relief are impracticable or unconstitutional should not cause us to take the position that there is nothing the Government can do for them. We are living in an age of organization. Manufacturing is organized; finance is organized; labor is organized; mining is organized; but our farmers are not organized. The farmer is essentially an individualist and the agricultural industry does not lend itself to either the corporate form of manufacturing or the association form of labor. The coöperative organization is the only practical form open to the farmer, and such organization as to a staple product produced generally throughout the country is very difficult. The result is that he finds himself paying high prices for everything he has to buy, produced under conditions that prevent excessive surpluses.

The farmer, however, goes right on producing crops greater than domestic consumption can care for, and he has a surplus which must find a market abroad. In such cases he receives very little benefit from tariff rates, and he therefore buys in a high market and sells in a low market. In wheat, especially, he gets as a rule the Liverpool price, less the cost of transporting his wheat from his railroad station to Liverpool, and thus the price is fixed, not only for wheat that he ships to Liverpool, but also for the wheat that he sells to be consumed in the United States. The farmer, also, pays the transportation rate upon everything that he buys. If he buys a Ford car he pays the Detroit price plus the transportation rate to his nearest railway station. If he buys a piece of agricultural machinery he pays the factory price, plus the transportation rate to his town, and so with all his other purchases. The farmer is the only American engaged in industry who pays the transportation upon both what he buys and sells. It is for this reason that the farmers of the West, far from markets, are constantly clamoring for lower transportation rates, and often demand such low railroad rates that if granted would throw every railroad serving them into bankruptcy. True, most of the farmers' troubles are economic, beyond relief at the hands of the Government, but this makes it all the more necessary that when the Government can give him real assistance that is sound, and rational, it should do so without any delay. When it can lower his transportation costs without injustice to anyone it should not hesitate to do so. The St. Lawrence Waterway furnishes this opportunity. Mr. Alfred H. Ritter, Transportation and Expert Specialist, has written a book upon this subject embodying the results of his studies of the transportation economics of the St. Lawrence project. He estimates the saving to the farmer in transportation rates upon grain to be about ten cents per bushel. He states that the average export movement of United States grain from Atlantic seaboard and St. Lawrence ports for the years 1921 to 1923 averaged 192,000,000 bushels, and upon this alone our farmers would have saved nearly $20,000,000 a year if they could have used the St. Lawrence Waterway. He also estimates there would be a general enhancement in price of five cents per bushel generally. Upon the last page of his book, under the Title "Conclusions," Mr. Ritter says:

> The probable transportation savings on grain alone are equal to five per cent on $800,000,000, while the annual transportation savings plus farm price enhancement are estimated to equal or exceed the total expense of the improvement properly chargeable to navigation, under the original project submitted to Congress by the International Joint Commission.

But it is not grain alone that will be transported over this waterway at a great saving of transportation costs.

The flour mills of Minneapolis in 1922 exported 659,000 barrels of flour. Mr. Ritter estimates that the St. Lawrence Waterway will effect a saving of $6 per long ton on flour shipped from Minneapolis to Europe.

Our packing house exports now amount to more than 2,000,000,000 pounds annually. Seventy-three per cent of this, or 1,560,000,000 pounds, originate in the territory tributary to the Great Lakes. Mr. Ritter estimates that upon shipments of these products from Chicago to London the St. Lawrence route will effect a saving of $17 per ton in transportation cost.

The heart of the automobile industry of the world is situated upon the Great Lakes. Exports of automobiles are increasing every year. The rail rate to the seaboard is high. It is estimated that over 115,000 tons of automobiles will be exported annually over the St. Lawrence route. I might name iron and steel products, agricultural implements, and many other commodities produced in territory tributary to the Great Lakes.

Thus far, I have spoken only of exports of commodities produced in Great Lakes territory, but imports of commodities used in this territory could also be carried over this waterway at a great saving of transportation costs. One of the most important of these is rubber. Our imports of rubber amount to more than 300,000 tons annually. Sixty-one per cent of the rubber imported is used by manufacturers tributary to the Great Lakes. This amounts to about 200,000 tons annually that could be carried over the St. Lawrence route, and Mr. Ritter estimates that this will effect a saving of more than $5 per ton in transportation costs, or more than $1,000,000 annually. This saving will effect every user of automobiles in the United States.

For the immediate territory affected imports of sugar will be the most important. The Great Lakes territory produces about 900,000 tons of beet sugar annually. The people of this territory consume about 1,800,000 tons annually, thus making necessary imports of 900,000 tons for their use annually. Every ton of this could come over the St. Lawrence route at an estimated saving of transportation costs of from $6 to $13 per ton. In addition there will be imports over this route of fish, rice, tropical fruits and nuts, wood pulp, manganese, etc., and other commodities, amounting to more than 3,000,000 tons annually, at a very great saving of transportation costs.

The Hoover Commission already referred to and the Department of Commerce estimate that from 21,000,000 to 25,000,000 tons of commodities are at present available for shipment over the St. Lawrence route annually, 80 per cent of which represents exports and imports. This will be very largely increased by the time the St. Lawrence route can be completed. At an average saving of only $2.50 per ton in transportation costs, this will amount to more than $50,000,000 annually. This represents a 4 per cent return on $1,250,000,000.

But it is not only lower costs of transportation through admitting ocean-going vessels to the Lakes that will be of economic benefit to the country. In connection with the improvement of the St. Lawrence for navigation, vast water powers will be developed, ultimately amounting to 5,000,000 horsepower. About 2,250,000 of this amount will be developed along the international section of the river between New York State and the Province of Ontario, one-half of which will belong to the United States. The plan calls for the immediate installation of 1,160,000 horsepower with provision of doubling this amount when a market for the power is available at an additional cost of only $32,000,000. When the full power on the international section is developed the cost for development and installation will be only about $100 per horsepower, which will permit its sale to New England and New York users at a much lower price than power can be produced for in any other way.

The construction of the St. Lawrence route with its incidental development of water power will save many New England industries from ruin.

Another great economic benefit to the entire country will be in the development of the nation's merchant marine. The people dwelling along our coasts have a keen realization of the value of a merchant marine flying the American flag, but the people of the interior, living far from our coasts, do not realize its importance and have been so indifferent upon the subject that legislation necessary to secure a permanent American Merchant Marine has never been enacted.

The St. Lawrence Waterway will add 4,000 miles to the coast line of the nation, an increase of nearly 50 per cent. When ocean vessels ply upon the Great Lakes there will be a visible demonstration of the desirability of maintaining the American flag upon the seas, and sentiment for an American Merchant Marine will then be as strong in the Middle West as it is now upon our coasts. In the great harbors of Chicago, Milwaukee, Superior, and Duluth, ships flying foreign flags will lead to a demand from that section that ships flying the American flag shall outnumber all others.

I have said nothing thus far about the cost of this improvement. The Hoover Committee estimates the navigation cost, that is the cost to the United States and Canada, at from $123,000,000 to $148,000,000 to be divided between the two countries. All additional costs would be chargeable to power which will take care of itself and cost the two governments nothing. It estimates the cost of the Lake Ontario-Hudson route at $506,000,000 and the so-called All-American route at $631,000,000 all chargeable to navigation to be paid by the United States alone, for no water power will be developed on either of them.

There is no comparison possible between these routes and the St. Lawrence route from an economic standpoint.

I have reserved for my last point the consideration of the objection that the St. Lawrence Waterway traverses foreign territory, and that from the standpoint of our national defense the St. Lawrence Waterway should not be favored. It is said that, should we be engaged in war with Great Britain, this waterway would admit her dreadnoughts into the Great Lakes, and that our great cities upon those Lakes could be easily destroyed by them. Fortunately, this matter has already been investigated by the United States Government. I quote from a report made by the Board of Engineers of the War Department in 1918:

> Such passage could be quickly and completely obstructed by the destruction of the locks in these canals by shell fire, notably in Canadian St. Lawrence River canals where all locks are within seven thousand feet of the United States main river shore, and some not over one half mile therefrom.

So if there was the slightest foundation for the theory that this ocean waterway might admit the English Navy into our Great Lakes and thus become a menace to us if we ever had trouble with Great Britain, our own War Department shows conclusively that every one of these locks and canals could be destroyed by shell fire from the American side without the slightest difficulty.

But there is another aspect of this question which should be considered, and that is that our determination of this matter should not be affected by any theory that the United States and Great Britain may hereafter become involved in war between themselves. If we are to assume that such is a probability, we should also recognize that should it ever occur such a war would end our civilization, and the world would be destroyed so far as we or our descendants would have any interest in it whatever.

On the contrary, the construction of this waterway as a joint undertaking by the United States and Canada will more strongly cement the friendship between us and our great neighbor to the North. We now have treaty rights giving us equality upon Canadian waters and Canadian equality upon American waters. Instead of being a menace to our National Defense it will furnish the greatest object lesson of friendly coöperation between two great nations that the world has ever known.

It is not within the purview of this paper to discuss the details of the plan of the improvement, its present status, and the steps necessary to bring it to a successful completion.

I have sought to show that it is a great national undertaking of tremendous economic benefit not only to the interior of the nation but to the entire country, and it should receive the support of every patriotic American.

The Salient Geographic Factors of the Colorado River and Basin

By HENRY F. JAMES
University of Pennsylvania

THE devastating flood which during the past summer laid waste the lower Mississippi valley was a solemn and sinister reminder that the imperative need of flood control has not been met. It calls sharply to mind, too, the great urgency of the whole problem of effective distribution and utilization of waters. A review, therefore, of the factors relating to this problem in the Colorado River Basin is not untimely.

Since the flood menace in the Lower Colorado Basin has been temporarily mastered, time is available for such a careful study of all phases of the problem as will result in a thorough understanding of the situation, *i.e.*, the utilization of water for irrigation, for domestic supply and for water power, together with such closely allied matters as state and federal jurisdiction, interstate control and distribution and international rights. These are problems of the first magnitude—the work of engineers and statesmen. The phase of the problem here presented is merely a description of the salient geographic factors of the Colorado River and its basin.

THE COLORADO BASIN

The Colorado Basin in actual territory is greater in extent than any one of the nations of Germany, France or Japan. Lying within the confines of seven states, it covers one-thirteenth of the area of the United States and a considerable section in northwestern Mexico. (See map, p. 88.)

Extreme variations prevail within the basin, from heavily timbered mountains on the high portions of the continental divide to desert areas, the most forbidding in the country; from places famed as summer resorts to those where the heat at times is almost unbearable; from crystalline mountains of solid granite to plains of silt, ash-like in their appearance and from the widest, the deepest, the longest and the grandest chasm on earth—the Grand Canyon—to a meandering shallow bed of soft fine alluvium.

This basin may be divided geographically into two, possibly three, regions. Two portions are decidedly distinct. The lower third is located in the states of Arizona, California and Nevada, and extends a short distance into Mexico. In general, its elevation is but little above sea level, though scattered here and there are ranges of mountains that rise to heights of 2000 to 6000 feet and depressions that fall below sea level. Its northern line of demarcation is a line of cliffs, the Grand Wash Cliffs. These present a bold, often vertical, step that leads hundreds or thousands of feet to the table land above. This is the region of the great American Desert, a land of excessive heat and aridity. Recorded temperatures have been known to reach 130° F.;[1] the annual rainfall in places is less than two inches.[2]

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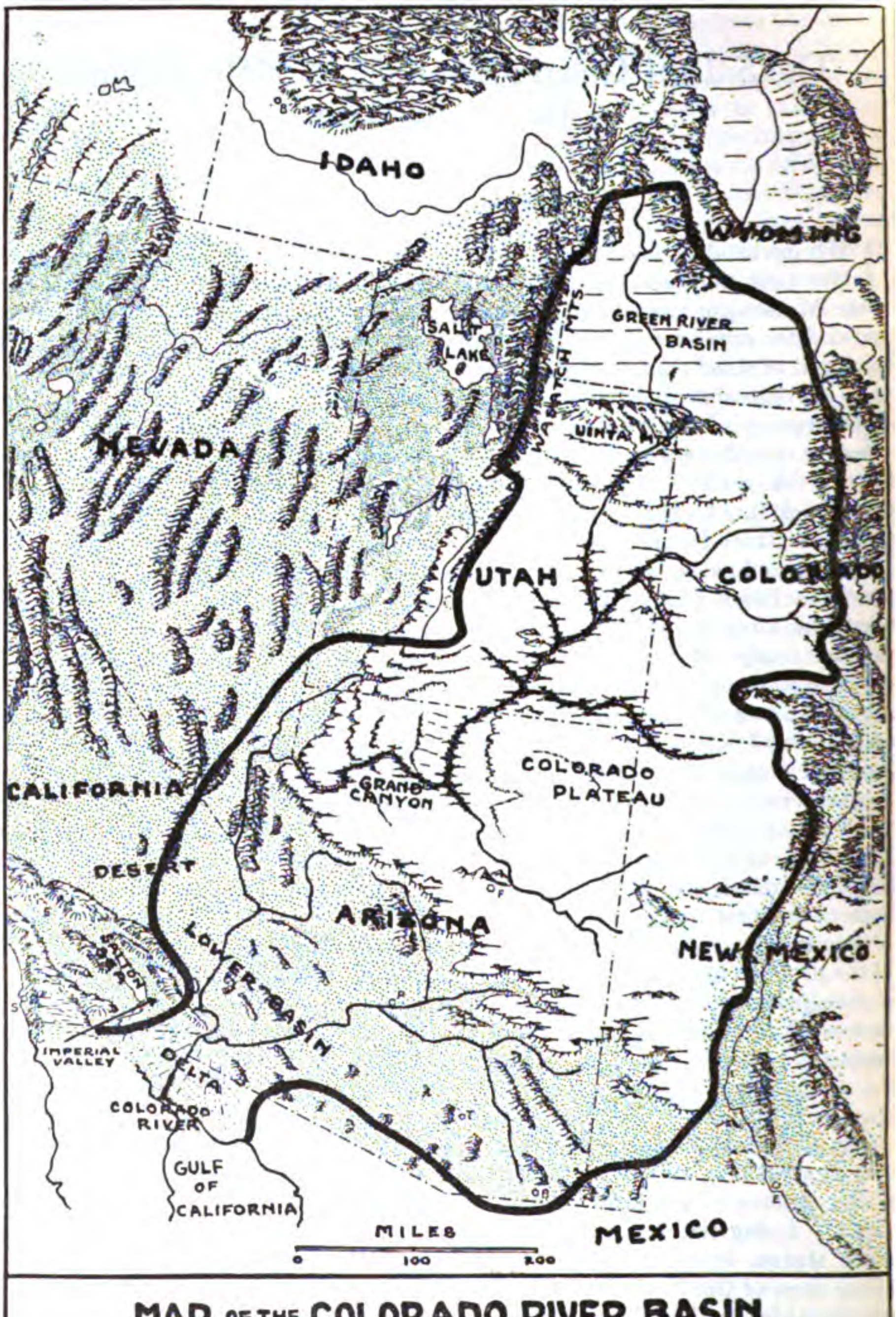
[1] Brown, John S., "The Salton Sea Region—California." U. S. Geological Survey, Water Supply Paper 497. Washington, 1923, p. 13.

[2] The annual precipitation ranges from an inch and a half to eight inches a year with temperatures ranging from 32° F. to 120° F. U. S. Geological Survey, Water Supply Paper 556, p. 12.



MAP OF THE COLORADO RIVER BASIN AND ASSOCIATED REGIONS.

PHYSIOGRAPHIC DIAGRAM COURTESY OF A. K. LOBECK

The prosperity of this southern section rests upon agriculture under irrigation, but its well-being is recurrently threatened by inundation during flood and its progress is retarded by a shortage of water during dry periods. In 1924 a loss totalling millions of dollars was sustained by the farmers in the Imperial Valley because of lack of water.

In many ways this lower section is similar to the Great Valley of California. Both receive the drainage of the large rivers of the interior. In the Gulf of California the Colorado River has built up its delta and in the California Valley the San Joaquin and Sacramento Rivers have formed theirs. The two areas are nearly at sea level. In each valley the displacement of the sea by alluvium has occurred within comparatively recent geological times. If the land should sink slightly less than 1000 feet, the California Valley would be flooded with sea water through the Golden Gate, while the tides of the Gulf of California would be carried far north of Yuma and the land would be flooded for 200 miles northwest of the present head of the Gulf. Both sections depend upon the melting snows of the higher areas for their well-being. Separating these two valleys are the high ranges of the Western Cordillera with their greatest break at the pass of San Gorgonia. Through this gateway pass the trains of the Southern Pacific Railway at an altitude of 2580 feet, thus binding the interior to the Pacific.

The northern two-thirds of the Colorado Basin is a land of mountains and plateaus with an upper basin in Colorado, Utah and Wyoming (Green River Basin, see map, p. 88) and a plateau section (Colorado Plateau, see map, p. 88) in Utah, Nevada, California and Arizona. In the upper basin the northern watershed is extremely rugged and fairly heavily timbered. Its streams flow through a succession of long, deep, narrow canyons transversed by short valleys that contain small tracts of arable meadow land. Severe winters prevail, but the growing season, although cool, is pleasant with enough warm weather for rapidly maturing crops. Broken plains and scarred plateaus of sedimentary origin are, however, the prevalent topographic features. The annual rainfall of only nine inches on the plains and meadow lands necessitates irrigation which is made possible by natural mountain lake storage and artificial reservoirs. Undeveloped reservoir sites, such as the Kremmling site, the greatest in Colorado, renders possible a more complete utilization of this region.

The plateau part extends from Lee's Ferry to Grand Wash Cliffs. In general, the elevation varies from 4000 to 8000 feet. Great ranges of snow-clad mountains with peaks ranging from 8000 to 14,000 feet are a conspicuous part of the landscape. All winter long on this mountain-crested rim, snow fills the gorges, half burying the forests and mantling the mountain tops. With the approach of the summer sun the life-giving waters are released to go tumbling down the mountain side in millions of cascades. In the words of Major John W. Powell,[3] "these ten million cascade brooks unite to form ten thousand torrent creeks; ten thousand creeks unite to form a hundred rivers beset with cataracts; a hundred roaring rivers unite to form the Colorado which rolls, a mad turbulent stream, into the Gulf of California." For more than a thousand miles along its course through the plateau section, the Colorado has cut for itself a canyon not continuous but broken here and there by narrow transverse valleys. The idea of the inaccessibility of the country can best be conveyed by the words of the same Major Powell. "Every tributary river in the plateau has cut another canyon; every creek has cut a canyon; every brook runs in a canyon; every rill born of a shower, and born again of a shower, and living only during these showers has cut for itself a canyon; so that the whole upper portion of the basin of the Colorado is traversed by a labyrinth of these deep gorges." It is a land of strange and weird physical features built on a gigantic scale. Hardly less noticeable than the canyons are the long lines of cliffs, great geographic steps that stretch for hundreds of miles across the landscape and rise frequently thousands of feet into the air. These cliffs are great blocks tilted in such a way that after one has climbed the steep, almost vertical face, he may descend by easy grades to the foot of a second escarpment. Great gateways have been cut through the cliffs by the intermittent streams making possible a journey from the plain below to the terrace above, from arid plains below to forests of pine and fir above with noticeable flora gradations in between. The surface of the plateau is also broken by low mesas that are dry and treeless with frequent gaunt surfaces of naked rock exposed. The region is further diversified by vast systems of fissures, huge deep cracks that are miles and miles in length. In times past from these crevices have poured floods of lava, great sheets of black basalt, that have covered mesas and table lands alike. Here and there along the fissures are found conspicuous landmarks, huge barren cinder cones that are probably the last dying evidence of great subterranean forces.

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[3] Powell, Major J. W. "First Through the Grand Canyon—Being the Record of the Pioneer Exploration of the Colorado River in 1869–1870."

The unnavigable rivers, buried deep in canyons like the great desert wastes, have prevented easy access to the region so that much of the plateau is relatively unknown. Even today in the canyon region from the mouth of the Green River to the Grand Wash, a distance of 500 miles, there are only three points at which it is possible to reach the river with a wheeled vehicle. In this remote region the Indian still retains his ancient culture. Thirty thousand[4] Hopi and Navajo Indians live on 20,000 miles of Indian reservation. Their life is hard. They still live in the fortress homes built by their ancestors on the easily defended tops of the mesas or follow their flocks and herds from water hole to water hole. The remaining part of the region is given over to a few ranchers and miners with irrigationists located along the more open stretches, but in many places not a living thing is seen, nothing but dry rock in the mountains and dry dust in the valleys.

THE COLORADO RIVER

The main artery of this basin, the Colorado River, is approximately 2000 miles long. It extends from Wyoming to Mexico. The characteristics of the river are the key to its many problems. The Colorado may be regarded as one of the most remarkable rivers in the world. It is the greatest undeveloped resource of the states through which it flows, for "it combines in proper sequence for complete use a large quantity of water, a great concentration of fall, reservoir sites for the control of flow, sites for power plants and several million acres of irrigable land below the stretch where power may be developed."[5]

It has frequently been called the

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[4] Smith, J. Russell, "North America," p. 472.

[5] Grover, Nathan C., Water Supply Paper No. 556, p. 3, U. S. Geological Survey.

Nile of America and, like the Nile, is subject to potential flood conditions during each summer. The Nile appears to be the greater stream.[6] Its drainage area is 5.7 times larger, with a 3.8 greater annual precipitation. The run-off per square mile of the Nile is 1.9 times greater, but the ratio of run-off to rainfall is two times smaller. The Nile also has a 10.8 times greater discharge than the Colorado. The maximum flow of the Nile, which occurs chiefly about September 1, amounts to approximately 353,000 second feet.[7] This is larger than that of the Colorado by over 200,000 second feet. The maximum flow of the Colorado occurs in May, June and July, a time most propitious for the irrigator. The minimum flow of the Colorado is only from 2500 to 3000 second feet as compared with 14,500 second feet, the minimum flow of the Nile. Thus the necessity for water storage such as is accomplished by the great dam at Assuan, Egypt, is shown to be more urgent still in the Colorado Basin. This fact is also clearly indicated in a study of the main flow of the two rivers. For the period 1894–1910, the main flow of the Colorado was not above 26,000 second feet, while that of the Nile amounted to 115,800 second feet.

The profile of the Colorado River is likewise one of its dominant characteristics. In 1800 miles, the river drops from an elevation of 13,579 feet [8] to sea level. The Nile has only a drop of 7000 feet [9] in a distance of 3473 miles. If comparisons are made with many other power-yielding streams of the United States, the potential power possibilities of the Colorado appear to be enormous. The Mississippi River from Cape Giradeau to the Gulf of Mexico has a drop of only eight inches [10] per mile. The power possibilities of the Tennessee are considered important, but that river has a drop of less than 500 feet between Knoxville and Paducah, a distance of approximately 700 miles.[11] The canyon section has great possibilities in the concentration of water power sites. Between Green River, Utah, and Parker, Arizona, there are at least twelve favorable dam sites where a continuous development of over 4,000,000 [12] horsepower can be made. In this respect its only superiors are the St. Lawrence and Columbia River Basins.

The Colorado River and its tributaries are hard-working streams. They bring to the delta, 105,000 [13] acre feet of silt per year. This amount would cover 105 acres to a depth of 1000 feet. In terms of yards, this equals 170,000,000, or an amount equal to two-thirds of the total material excavated in the construction of the Panama Canal. Six million average railroad cars would be needed to transport this material. Driftwood is also carried during flood periods. In the flood of September, 1923, hundreds of logs 20 to 30 feet long and 2 to 3 feet in diameter passed through the Grand Canyon.

With this description of the geographical conditions of the Colorado River and its Basin as a background, we may now turn to a brief analysis of some of its important problems.

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[6] All statistics relative to this comparison taken from the U. S. Geological Survey, Water Supply Paper No. 289, pp. 26–27.

[7] Second foot is an abbreviation for cubic foot per second and is the rate of discharge of water flowing in a stream, one foot wide, one foot deep, at a rate of one foot per second.

[8] Clark, W. G., "The Colorado River," p. 7.

[9] Encyclopedia Britannica, 11th edition, Vol. 19, p. 692.

[10] *Ibid.*, Vol. 18, p. 604.

[11] Brown, R. M., "Utilization of the Colorado River," *Geographical Review*, July, 1927, p. 456.

[12] U. S. Geological Survey, Water Supply Paper 556.

[13] *Ibid.*, p. 16. See table.

THE FLOOD MENACE OF THE COLORADO[14]

The river emerges from the hills and canyons as a law-abiding stream for ten months of the year. For the remaining two months in the early spring, it is almost uncontrollable. Instead of a blessing it then becomes a threat to man and all his works in the Lower Basin. The value of the property that is menaced by these floods exceeds $100,000,000, while at least 50,000 people are living in the shadow of just such a great catastrophe as occurred in 1905 and was repeated over a very limited area in 1909. In 1921 a recurrence of these disasters was prevented only by a shift of the wind that drove the waters back. Man's existence here is precarious in the extreme for on the holding of a long thin line of granite-faced levees depends his safety.

The geographical nature of the country itself makes floods possible. Some thousands of years ago this endangered land was part of the Gulf of California, a great arm of the ocean that extended 150 miles inland from its present limits. In fact, its waters probably washed the slopes of the San Jacinto and San Bernardino Mountains and covered a land that is now arid mountains and desert plains. The Colorado River emptied its waters into an eastern arm of this body of water that reached nearly to the present site of Yuma. Into it has been deposited through aeons of time the mud and rock scoured from high mountains and worn out of deep canyons. Inch by inch the water was driven back until this eastern basin was entirely filled. Onward spread the delta until it reached the eastern base of the Cocopa Mountains. Thus was formed a dam that separated the Gulf into two parts, one entirely cut off from the ocean. The dam increased in height and breadth from decade to decade until today the dam above sea level is nearly 100 miles wide. On top of this delta bridge flows the Colorado River at a height of approximately 30 feet above the sea and actually higher than the adjacent country. To the northwest lies the old Gulf bed, now a region of interior drainage with but a remnant, the present Salton Sea, left of that historic ocean arm. The lowest part of this basin is 300 feet below the level of the river and only 70 miles away. To the south lies the recent delta land with the Gulf of California 50 miles in the distance. The waters of the Colorado pass down the gentle slope towards the Gulf.

The direction of the river is unusual for a grade nearly ten times as steep leads into the Salton Basin and Imperial Valley. Forty-three thousand people, at least the population of the Imperial Valley of California, desire a continuation of this condition. They wish for no replica of the biblical flood. A modern system of levees has been constructed at which the river in recent years has really pounded in vain. It is a risky situation at best, for not always has the river flowed in its present channel. Time and time again in the ages past the geologists tell us that the river has turned its waters into the interior basin and at a later date turned again towards the Gulf. Up until 1905, for many hundreds of years, it has flowed untroubled to the Gulf. The great interior basin became practically empty of water through evaporation and seepage for the run-off from the mountains that surround the sink is too slight to maintain a permanent water body in this region. From a great arm of the ocean it had become a desert waste, sun-baked and desolate. Engineers were determined to harness the Colorado, making of its water a blessing to this parched land instead of a curse. They found the river difficult to handle. Canals that made possible the proper distribution of the water quickly silted up. New channels had to be built constantly as a greater and greater demand for water came with increased population. Man thus weakened the natural dams that kept the river in its proper channel and also neglected to provide sufficient protective head works for the canal that had a gradient much greater than that of the river. The result was that, in 1905 and 1906, during the periodical floods, the river broke through and hurled 87 per cent of its volume into the Salton Basin. Only after sixteen months of effort and an expenditure of $2,000,000 was the river turned back into its old channel. But the battle is not over. The river is bringing down its 6,000,000 carloads of silt and mud each year, a hundred thousand acre feet of damming material. Man in order to hold the balance of power has thrown in 6000 carloads of rock. How long can this unequal warfare be continued? Each year the threat of disaster is renewed and the situation becomes more and more critical. With the increase of cotton and alfalfa fields, orchards and vineyards, another break would be a calamity. The levees are not positive preventives. Something must be done to regulate the flow of the stream during its violent periods. The building of dams and the ponding of its waters in a few of its great canyons is the only permanent preventive of a possible catastrophe.

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[14] References consulted in the study of floods are:

(1) An article by James H. Gordon, *Monthly Weather Review*, February, 1924. "Problems of the Lower Colorado River," pp. 95–97.
(2) An excellent scientific discussion of river control in the Colorado River Delta by H. T. Cory, in Paper No. 1270. "Transactions of the American Society of Civil Engineers," Vol. 76, 1913.
(3) Mendenhall, Walter C., U. S. Geological Survey, Water Supply Paper No. 225.
(4) Entenman, P. M., "Flood Danger in the Colorado Delta," *Engineering News Record*, March 31, 1927.
(5) Priest, R. M., "Channel and Levee Conditions in the Colorado Delta," *Engineering News Record*, March 17, 1927.
(6) Sykes, Godfrey, "The Delta and Estuary of the Colorado River," *Geographical Review*, April, 1926, Vol. 16, No. 2.

THE PROBLEMS OF IRRIGATION

The streams of the Colorado Basin are already utilized for irrigation to a considerable extent. From a probable beginning on the upper Greer River in Wyoming, the irrigated lands had increased in acreage until, in 1922,[15] the total area irrigated amounted to 2,398,000 acres. Of this amount approximately 1,500,000 acres[16] were irrigated in the Upper Basin. This was an increase of approximately 1,000,000 acres since 1899.

Irrigation is necessary here because of the climate. Nowhere do the areas that are possible to irrigate have a rainfall of over eight inches. Summer temperatures of 100° F. are not uncommon even in the plateau section of the basin. In the Lower Basin the chief climatic characteristics are the excessive summer heat and dryness. During the five hot months, the temperature will average over 90° in the lowlands. The climate is trying for man and beast. The air is not stagnant. Gales with their accompanying sandstorms that last for a few hours are not uncommon. The heat and the wind together keep the surface very dry and cause excessive evaporation from exposed water bodies. Rain in

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[15] See table on page 94.

[16] LaRue and Holbrook, U. S. Geological Survey, Water Supply Paper No. 556, Appendix A, Water Supply, p. 109.

TABLE I.—IRRIGATED AND IRRIGABLE AREAS IN THE COLORADO BASIN IN 1922.
(Extracted from an article by R. M. Brown, *Geographical Review*, July, 1927)

	Areas in Acres		
	Irrigated 1922	Additional Irrigable	Total
Upper Colorado Basin	1,477,000	2,740,000	4,187,000
Lower Colorado Basin	521,000	1,467,000	1,988,000
Gila Basin	430,000	400,000	830,000
Totals	2,398,000	4,607,000	7,005,000
Wyoming	235,000	522,000	757,000
Colorado	800,000	1,460,000	2,260,000
Utah	386,000	377,000	763,000
Nevada	7,000	7,000	14,000
New Mexico	50,000	408,000	458,000
Arizona	493,000	1,312,700	1,806,000
California	426,700	520,300	949,000

the form of cloudbursts occurs at times. The flood waves so caused are responsible for practically all of the desert erosion, but the total rainfall annually is not over eight inches.[17]

Irrigation is possible here because of the supply of surface and ground water available. From the former source practically all dependence will be placed by future reclamation projects. The amount of surface water used at present amounts to 6,700,000 acre feet (1924), of which slightly over 3,000,000 acre feet were used in the American section of the Lower Basin and 780,000 acre feet in Mexico. The United States Reclamation Service believes that eventually the Upper Basin will require annually for direct use 6,550,000 [18] acre feet of water and the Lower Basin 8,282,000 acre feet. There will also be some loss through evaporation and seepage from river, canal and reservoir. The mean annual flow of the Colorado at Yuma, Arizona, from 1894–1911 was 12,388,000 acre feet.[19] In 1894, however, it amounted to only 5,390,000 acre feet, while in 1909 the discharge equaled 26,000,000 acre feet. It can thus be clearly seen that the maximum development of irrigation in the Colorado Basin cannot be obtained without the development of a comprehensive plan for storage and regulation of the waters of the Colorado River. The Lower Basin at present is beginning to feel a shortage of water during exceedingly dry periods.

The problem of storage and regulation is difficult because of the number of states and nations involved. The border states have not yet reached an agreement in regard to the distribution of water between them, although the Federal Government, in 1922, through the person of Herbert Hoover, brought the state delegates together in Santa Fe, New Mexico. The result was the Colorado River Compact,[20] which was agreed to at that time by all the participating states with the exception of Arizona. Since then Utah has rescinded her action while the adherence of California is conditional on the building of the Boulder Canyon Dam by the Federal Government. An international agreement is also necessary because Mexico has approximately a million acres of land irrigated or available for irrigation in the Colorado Basin. To further complicate the matter the Mexican projects have been developed largely through American capital and water for the Imperial Valley (California) is brought through the Mexican-American Canal, which is largely located in Mexican territory.

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[17] U. S. Geological Survey, "Some Desert Watering Places," Water Supply Paper No. 224, pp. 12–13.

[18] Includes the amount that will eventually be diverted in the vicinity of Denver to the Mississippi watershed, and in Utah to the Great Salt Lake Basin—in the neighborhood of 440,000 acre feet.

[19] Cory, H. T., *op. cit.*, pp. 1210.

Two engineering problems in connection with irrigation are serious. One is the danger of diverting water from a wide, erratic stream that flows through a shifting channel as does the Colorado on the top of the delta ridge dam. The other is the difficulty of keeping open canals in a region where the water is so heavily charged with silt. During flood stages the water carries all the silt that it is able to transport. The size of the silt particles depends upon the speed of the stream. Records kept of conditions in the Imperial Valley irrigation area indicate that the beds of many of the canals were raised between two and five feet in a period of three years. This reduction in capacity which is slightly noticeable in the larger canals and especially critical in the smaller laterals makes a larger number of canals necessary or constant dredging in order to keep the channels open. The cost of keeping the canals open varies from $50 to $60 per mile.[21] The Imperial Water Company No. 1 maintains in the neighborhood of 400 miles of canals.

It has also been noticed that the soil in places is heavily impregnated with alkali. Alkali is the accumulation in the surface layers of excessive amounts of soluble salts, mainly chloride and sulphate of sodium. All desert soils, especially those of the silt variety, that are fine enough in texture to permit capillary rise of water through them, are likely to become alkali. The Bureau of Soils of the U. S. Department of Agriculture has presented a very unfavorable report[22] regarding the alkali conditions of the soils of the Imperial Valley. It advised the planting of crops, such as sugar beets, sorghum and date palms that are suited to alkaline soils and to abandon as worthless the land which contained too much alkali to grow these crops. The warning was repeated in a later report. The repeated application of water to these lands will have a tendency to increase the alkalinity. This condition will then develop a problem of drainage that has not yet seriously added to the farmers' burden.

Still another fact in regard to irrigation must be realized. What has been the result of irrigation projects already established by the Reclamation Service? Is there a noticeable need at the present time for further development? Bowman[23] states that "the total farming population upon the twenty-four national irrigation projects of the West after twenty-five years of government aid and generosity is but 137,000, a population equal to that of the city of

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[20] For the complete text of the compact see 67th Congress, 4th Session, House of Representatives, Document No. 605. An excellent discussion is also given in the "Colorado River, History, Seven States Compact and Future Development," by Walter Gordon Clark.

[21] Cory, H. T., *op. cit.*, pp. 1284–1285.

[22] Field Operation of the Bureau of Soils, U. S. Department of Agriculture, 1901. A later report appeared in 1903.

[23] Bowman, Isaiah, "The Pioneer Fringe," *Foreign Affairs*, Vol. 6, No. 1, October, 1927, p. 61.

Hartford, Conn., or Grand Rapids, Mich." He further emphasizes the fact that "the most trifling improvement of agricultural practice in settled communities will accomplish much more in the production of agricultural products and the growth of population than all the millions that have been poured out upon the irrigation projects of the West in a quarter of a century." Further irrigation development at present appears of doubtful necessity.

POWER DEVELOPMENT

Power development as the keystone of the arch of Colorado River conditions is the hope of those interested. By the sale of power they expect to pay largely the high cost of flood control and irrigation water storage. From a production point of view, their hopes are justified. Nature has been so kind that the average discharge of the river (see page 7) together with its steep gradient and numerous power sites is sufficient to develop from five to six million horsepower of hydro-electric energy. The U. S. Geological Survey has recommended thirteen power sites[24] that would produce 5,743,000 horsepower with maximum use of the water in the Upper Basin.

Three problems vital to the full realization of this ambitious program must be considered. In the first place, storage for flood control and for power development is in striking conflict.[25] "Flood control reservoirs need to be kept empty and ready for flood service, while power development reservoirs need to be kept full to ensure steady power." The noted engineer, Arthur E. Morgan, believes that it is a grave mistake to try to combine them. The question of cost is also paramount. The cost of the Boulder Canyon Project alone, including the erection of a power plant, is estimated in the neighborhood of $75,000,000. If the cost is to be met by the sale of electricity, the question of distance must be considered. It is 250 miles from Boulder Canyon to Los Angeles, the principal market for power. San Diego is approximately 300 miles away; Yuma, Arizona, 250 miles. The principal mining districts in Arizona and Nevada are at a distance greater than 250 miles. Engineers estimate that the Boulder Canyon power would cost $50 per horsepower delivered in Los Angeles where power is now generated by steam at a cost of $40 per horsepower. It appears highly problematical whether power generated in a desert hundreds of miles from available market can be put on a paying basis for many years to come if at all within the lifetime of the men backing the proposition.

Problems of power, flood control, water diversion for irrigation and urban purposes and the disposal of silt cannot be solved singly. Together they make up the problem of the most economic utilization of the waters of the Colorado. The flood menace must be conquered within a few years or disaster will result, but consideration of the other factors of the equation is essential, or else in providing for the immediate present mistakes will be made that will prevent the fullest utilization of this great river and postpone indefinitely the complete development of the adjacent states. At present, there are many disputed points. Dam sites cannot be agreed upon. State rights vs. federal control is a burning question. Private corporations are fighting the national government for control. The interested states are unable to agree. These differences will no doubt be ironed out eventually. It is a gigantic task, however, that must be studied carefully and scientifically in order that the Colorado River, now a menace, will be eventually harnessed for man's benefit and man's enjoyment.

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[24] See table, p. 46, Water Supply Paper No. 556, U. S. Geological Survey.

[25] Morgan, Arthur E., "The Mississippi." *Atlantic Monthly*, November, 1927.

Legal Problems in Colorado River Development

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In the present article it is my purpose to discuss but a very limited number of the legal questions in Colorado River development. Numerous briefs have been written by firms of competent lawyers whose professional duty it is to give advice on such questions as whether or not Arizona is correct in asserting her right to tax each unit of power developed within her borders, whether or not Denver may divert water from the Colorado watershed, whether or not there is any possibility of Los Angeles being able to secure title to water which it is anticipated will be stored in Boulder Dam, and a score of other important issues of similar or different nature. Accordingly, in the selection of the subjects treated I have been guided by the belief that a person occupying the position of a disinterested observer and student will be performing the best service by calling attention to the broad outlines of a plan for the improvement of this interstate stream. To such a plan I have devoted major consideration, with the result that many obvious legal questions are omitted from the present paper. But although these be omitted it is with the hope that the plan suggested may prove worthy of consideration and thereby compensate for the neglect of other material.

The topics which are to be discussed in the succeeding paragraphs may be listed as follows: the present importance of the Compact drafted at Santa Fe in 1922, the legal background of the Compact, the proper sphere of activity of an interstate Colorado River commission, and a suggestion that conservancy districts be organized in the interested states for the purpose of contracting with each other relative to Colorado River matters.

Present Importance of the Compact

Without doubt the Colorado River Compact drafted at Santa Fe, New Mexico, in 1922, will continue to be the starting point of all discussion for any plan finally agreed upon to further Colorado River development. Fundamental groundwork was laid by the drawing of that agreement. Nor has the stormy course experienced by the Compact during the past five years served to make the preliminary work of less value. Certain underlying issues are now more widely apparent than was true of the situation several years ago, in spite of the fact that the seven-state treaty is not effective. Arizona's consistent refusal to ratify, California's ratification conditioned upon storage, and Utah's recent step in rescinding her earlier ratification, together with Colorado's insistence that not a shovel of earth be turned for the development of any project in the Colorado below Lee's Ferry before the Compact shall have been accepted by at least six of the seven states—a point of view at one time written into the Swing-Johnson bill but now replaced by the idea that construction may proceed upon acquiesence of the Compact's terms by only three of the interested states—have all combined to make the Compact the most important single document in the entire Colorado River controversy.

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[1] Author of "The Colorado River Compact," pp. xxiv, 527, published by Southwest Research, Los Angeles.

LEGAL BACKGROUND OF THE COMPACT

From a study of the minutes of the twenty-seven meetings of the Colorado River Commission at which the different paragraphs of the Compact were drafted, and from a careful investigation of other source material, I am convinced that the sponsors of the proposed seven-state agreement thought that such a treaty was necessary as a means of circumventing the prior appropriation system of determining water rights on the Colorado. The *Wyoming* v. *Colorado Case*, 259 U. S. 419, decided by the Supreme Court of the United States on June 5, 1922, held that, as between two prior appropriation states, water rights on an interstate stream would be determined upon the basis of prior use irrespective of state lines. This had been for many years a contested point in water rights litigation involving interstate streams, but the possibility of a decision such as the Supreme Court gave in the Wyoming-Colorado case, had been foreseen by those familiar with the question. Coming as it did during the hearings of the Colorado River Commission in different cities of the Southwest preliminary to the Santa Fe meetings, the decision in *Wyoming* v. *Colorado* confirmed the fears of representatives of Colorado and other upper basin states that the stage was being set for the permanent appropriation of Colorado River waters by water users of the lower basin states to the everlasting detriment of the upper basin.

The chief factor which contributed to this belief was the more rapid movement of population from the Eastern centers to areas in the lower basin, particularly southern California, than to the areas of the upper basin. Along with the population came an almost insatiable desire for water for domestic and agricultural purposes because of the general aridity of the lower basin areas. More than this, a large population meant a corresponding political and financial power to build the works required in the process of placing the waters of available streams to beneficial use.

Little wonder, then, that legal representatives of the upper basin states upon surveying, on the one hand, the rules of law applicable to problems of this kind and, on the other, the trend of events pointing directly to the appropriation of large quantities of water for beneficial purposes in the lower basin at an earlier date than the water would be needed in the upper basin, were spurred by the *Wyoming* v. *Colorado* decision to renewed efforts in their attempt to modify the prior appropriation doctrine of water rights with respect to the waters of the Colorado. States of the lower basin had nothing to gain by changing the prior appropriation doctrine so long as development continued under the appropriation system; states of the upper basin had everything to gain by changing that system, for if the prior appropriation doctrine continued to apply, the states of the upper basin might find that, due to its prior application to beneficial use by the lower basin, no unappropriated water would remain for use in the upper basin at the time that the upper basin becomes ready to use it.

While it is true that states of the lower basin had nothing to gain by changing the prior appropriation doctrine so long as development continued under that system, it should be noted that such development, as a matter of fact and until a change of policy by the Federal Power Commission, is at an end unless some uniform plan is made for the Colorado's development. For several years the Federal Power Commission has been reluctant to grant permits for Colorado River construction because of the obvious benefits to be realized from the use of a coördinated plan of which each individual project should be a part. But to projects in which large sums have been expended in preparatory work, such as the Girand project, the Federal Power Commission is said to stand ready to give preferred consideration upon the withdrawal of the general order of suspension of permits. This general order may be withdrawn at any time that the Commission deems reasonable. That is, if the members of the Commission believe that it is unlikely that a unified plan can be agreed upon by the seven states, they will perhaps allow construction of the better projects to proceed without reference to a general plan. This will, of course, make possible the appropriation of water and the vesting of rights.

The Proper Sphere of Activity of an Interstate Commission

One of the legal questions of prime importance in Colorado River development is the question of whether or not the seven states may enter into a compact and thereby achieve the legal result of dividing the water of the Colorado in the manner attempted by the terms of the Santa Fe agreement. That Compact, it will be recalled, attempted to apportion a definite amount of water to the upper and lower basins respectively.

But can the apportionment of the waters of an interstate stream, even though ratified by the legislatures of the states concerned and by Congress and in the event that it is finally determined by the courts to be legally sound, be of any practical benefit if there is not a sufficient amount of water in the river to satisfy present users and those who wish to become appropriators, some of whom now have their applications on file with the state commissions or with the Federal Power Commission or both? Is it within the legal power of a group of states to enter into an agreement with one another, such agreement being sanctioned by the legislative branch of the Federal Government, and by the terms of said agreement superimpose a new system for the determination of rights in the waters of an interstate stream which may conflict with the legal methods already established by the individual states for the determination of water rights? Is it not true that the first step in Colorado River improvement by the coöperative effort of the interested states should be a survey of the water rights now recognized and vested under the laws of the several jurisdictions? Present users must be taken care of regardless of what particular method of improvement is finally selected.

It is also probable that certain applications now on file with the various states would be found to be entitled to priority under the laws of the states having jurisdiction. Such inchoate interests should also be included in the survey. With these data at hand an interstate commission, called a Colorado River Authority in my book, would be in a position to recommend those steps for the development of the stream which would best serve the interests of all parties. Members of such a commission would then definitely know the particular rights affected by any proposed construction project and could attack condemnation and other specific problems with some hope of making progress.

The whole purpose of the present agitation for Colorado River development is, of course, to increase the quantity of water available for beneficial use. This quantity will be determined by the particular plan adopted for the development of the stream. And this is one point at which the Compact of 1922 has proved entirely inadequate. No mention was made of particular projects. Let it be clearly understood that I do not say that more progress could have been made the past five years if the Compact had referred to definite engineering programs, for perhaps the plan worked out was as much of a forward step as could then be taken. But that it was inadequate, the last five years of inaction and controversy abundantly establish.

The Compact spoke of millions of acre-feet of water without a word about plans for making that water available. It attempted to tamper with the acknowledged system of water rights by asserting that the upper basin should have 75,000,000 acre-feet for use within the upper basin during each ten-year period, and that a like quantity, increased by a million acre-feet per year, should be available for use in the lower basin during each ten-year period.

But to declare that water shall be used in certain quantities in designated places does not make the water available for such use. This was realized by California when the legislature of that state attempted to couple a tangible project—Boulder Dam, contemplated by the Swing-Johnson bill—with assertions of the Compact concerning water rights. The manner in which the California legislature proceeded was to make construction of a storage reservoir in the lower basin a condition precedent to California's acceptance of the provisions of the Compact relative to the fixing of water rights. This action clearly shows that California appreciates the fact that an abstract statement concerning rights to water, which is not as a matter of fact available for use, is of little or no value.

The only interstate agreement which will finally gain sufficient support to result in ratification will be one, I believe, in which provision is made for engineering surveys to determine upon the best plan to make available the largest possible quantity of water and also to serve all other purposes of river development such as flood control and power generation. Coupled with these provisions there may very properly be a declaration of the manner in which rights to the water about to be made available may come into being.

In other words, when an inventory of all the water rights now existing on the Colorado shall have been made by an interstate commission, and when a survey of the most economic engineering plans for the development of the river shall have been completed, we will know how much water will be added to the present available supply. Knowing this, and knowing that the particular project determined upon for the development of the stream is the best and most economic method, the interstate commission could then undertake the next problem of suggesting the method or methods of creating legal rights to the water about to be made available. This portion of the work of the interstate commission might take the form of a suggested uniform water code for the interested states to be applicable only to the quantity of water made available by the completion of the engineering project finally selected.

The procedure outlined in the preceding paragraphs may seem to require too long a period of time before results could be realized. But those who have watched the situation during the past five years must be convinced that actual construction of Boulder Dam, the most widely heralded project on the Colorado, is now more uncertain than has been the case at any previous time within the past five years. This is due to the fact that instead of making a survey of the whole river for the purpose of determining the best manner of developing it as an asset of the entire region, and therefore of the nation, greatest emphasis has centered around the question of the most feasible method of securing flood control for Imperial Valley and a water supply for southern California. And there are some who go to the extent of saying that plans now proposed for these specific purposes are not at all the most economical which might be devised to realize the desired ends.

Events of the past half decade clearly show that the most essential single thing for an interstate Colorado River commission to do is to provide a forum where the contentions of all parties may be submitted for consideration upon their merits. These contentions may relate to engineering, economic, or legal data. But whatever their nature, they should be available for scientific study and analysis by all interested parties. Had there been such an interstate commission in operation the past five years it is quite probable that the assertions of the Arizona High Line Association and of the sponsors of a gravity line from the mouth of the San Juan across southern Utah, across Nevada and California to the Imperial Valley, either would have been verified or exploded by the present time in a manner carrying conviction. As it is, these questions and a host of others of similar nature, to say nothing of the legal controversies, serve only to confuse the public.

CONTRACTING CONSERVANCY DISTRICTS

Assuming that an interstate compact between the seven states will some day provide for an interstate commission whose duties will approximate those above described, and assuming further that such commission will have completed the inventory of water rights existing prior to construction of any particular project on the Colorado and will have heard all arguments relative to the best engineering plan to be adopted, thus fostering an intelligent public opinion, and assuming further that such a commission also will have aided in working out the legal questions centering around the determination of water rights in the use of the additional quantity of water made available by the proposed new construction, the next step in Colorado River development should be the organization of conservancy districts to contract with each other relative to existing water rights and water rights which will be brought into existence by reason of the appropriation of water not now available but which will become available upon the construction of the engineering works finally believed to be the most desirable. In fostering the organization of these districts in the interested states an interstate commission would have an important part to play.

The general plan of organization of these districts might be similar to that of the conservancy districts of Ohio and New Mexico. These districts, analogous in some respects to irrigation and drainage districts of the various states, permit a large degree of local control of the coöperative enterprise. The primary purpose of the legislative act of Ohio is to provide a means whereby the owners of property in areas threatened by floods may organize for their mutual protection. However, this act[2] also states that its purposes include that of "providing for irrigation where it may be needed." New Mexico's statute,[3] as might be expected, places more emphasis upon the reclamation features of the conservation program, though provision is also made for meeting flood dangers.

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[2] 104 Ohio Laws 13–64, February 5, 1914.

[3] Laws of New Mexico, 1923, Chapter 140, pp. 211–278, March 12, 1923.

In other words, both Ohio and New Mexico have provided a method by which the owners of the land affected by a particular project may determine the manner in which that project shall be controlled and administered. This manner of dealing with the problem conserves the benefits of local self-government. By means of the organization of a number of conservancy districts in the states of the Colorado Basin, the groundwork would be laid for a series of contracts among such districts with respect to definitely determined water rights. But before these districts can be organized, the route of the main aqueducts which will eventually constitute the best unified system of development to serve the largest number of interests or purposes in the entire basin must be determined. Only in this manner will it be possible to know the areas which will be directly affected by the development and therefore included within the proposed conservancy districts.

Looking more closely at the language of the New Mexico Act we find that it provides that the district court sitting in and for any county of the state, or any judge thereof in vacation, is vested with jurisdiction to establish conservancy districts. These districts may be entirely within or partly within and partly without the judicial district in which said court is located. A partial list of the purposes for which the conservancy districts may be formed is as follows: preventing floods; regulating stream channels by changing, widening and deepening the same; regulating the flow of streams; constructing irrigation and drainage works or systems; coöperating and contracting with the federal or any state government to promote the agricultural resources and marketing facilities of the district.

The manner of organizing the district is by petition filed in the office of the clerk of the court vested with jurisdiction. Such petition is to be signed by one hundred owners of land or by a majority of the owners of land situate within the limits of the territory proposed to be organized into a district. In the event that private or public corporations own lands within the proposed district, such corporations are proper parties to sign the petition. Moreover, any city interested in some degree in the improvement, upon proper action by its governing body, may alone file the petition already mentioned. Following the hearing of any protests against the organization of the district, the court is to declare the district organized and give it a corporate name by which it is thereafter to be known.

The remaining articles of the New Mexico Act refer to the powers and duties of the board of directors of the conservancy district, appraisals of benefits, and financial administration.

Upon the organization of these conservancy districts in the states interested in the development of the Colorado the way would be cleared for a series of contracts between the various districts as parties, by which to determine the details of the use to which available water might be placed and the terms of remuneration for such use. Plans for the necessary construction work might also be handled by contract between the districts concerned.

In accordance with the Act of August 11, 1916,[4] conservancy statutes of the kind suggested would also be applicable to the public lands of the United States lying within the conservancy district, upon the approval of the Secretary of the Interior and subject to certain exceptions mentioned in the act. Briefly stated, the purpose and effect of this statute is to empower the Secretary of the Interior, following the presentation of a proper application therefor, to investigate the plans and financial and physical resources of irrigation districts theretofore or thereafter organized pursuant to the law of any state, and, if he shall find and conclude that any such district has planned and is executing an altogether meritorious and feasible irrigation undertaking, to grant his approval of its plan and undertaking, provided a majority acreage thereof is not unentered land. Upon such approval and upon compliance by such districts with certain conditions in said act specifically set forth, all unentered public land and land which has been entered, but upon which final certificate has not issued, shall be amenable to the state laws governing the district to the same extent and upon like terms as are privately owned lands within said districts.

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[4] Chapter 319, 39 Stat. 506.

CONCLUSION

In conclusion it may be said that the Compact drafted at Santa Fe in 1922, which has been the subject of innumerable conferences since that date, will perhaps never be ratified by the seven states in its present form because of its failure to mention a specific engineering project to make additional water available. Its inadequacy in this respect creates a situation in which the upper states cannot allow any construction to proceed in the lower basin before the compact is ratified, and the lower states, particularly California, cannot afford to ratify until the support of the entire basin for storage facilities in the lower basin is guaranteed to the lower states. But an understanding of the present Compact and the discussions which have centered around it, are of the greatest importance if the fundamental issues which surround the Colorado are finally to be resolved into a unified plan of action.

As one observes the present situation he is led to inquire if the experience of the past five years has not shown that a new approach to the problem would be advisable. Instead of attempting to apportion the waters of the stream before a unified engineering plan has been worked out and accepted by the seven states, the United States and Mexico, why should there not be an interstate commission created by the use of the interstate compact clause of the Federal Constitution for the purpose of examining all proposed plans for the development of the river? By means of the discussion which would accompany such a process there is reason to believe that confidence would be developed so that every representative and senator from the interested states would be ready to vote for the particular project decided upon. To develop this confidence should be the first and fundamental purpose of an interstate commission. It does not seem possible to develop it by discussing rights to water which is not yet available for use. But if everyone believed that a specific engineering plan for the development of the entire river would get the maximum use out of the stream, a continuing interstate commission would have something upon which to proceed.

Engineering and Economic Features of the Boulder Dam

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ALTHOUGH the present agricultural and commercial development of the Colorado River has been accomplished during the past 75 years, practically four centuries have elapsed since the first white man gazed upon its waters. During these centuries, the information left by the diaries of the intrepid Padres and explorers from time to time have given brief mention of the high waters and terrific floods which prevented their crossings or fought them in their endeavors to sail up the Lower River below Yuma.

The Colorado River has a total length of approximately 1750 miles, a drainage area of 244,000 square miles and a total annual water supply of approximately 21,700,000 acre feet. The larger portion of this water is supplied by the melting snow from the summit of the Rocky Mountains in western Colorado and Wyoming, but an appreciable portion is also furnished by the drainage area below the junction of the Green with the Colorado, a section subjected at certain seasons to violent storms of short duration commonly known as cloud-bursts. The effect of these storms and of the fluctuation in the melting snows is indicated by the differences in the river flow, annual discharges as great as 26,000,000 acre feet and as low as 8,000,000 acre feet having been recorded at Yuma.

Magnitude of Floods

While records have indicated the low flow of the river at less than 1300 cubic feet per second or second feet, in flood season—May and June—the discharge at times is more than 200,000 second feet by actual measurement, and the flood of 1884 was estimated at 384,000 second feet. Marks left by high water at some time previous to known records would indicate a discharge greatly in excess of this figure and reaching possibly 500,000 second feet.

Silt

In addition, due to the flood characteristics and to the effect of heavy storms on a large portion of the area, as well as the soil and topography of the country through which it flows, the river carries a tremendous burden of silt estimated from direct measurements at approximately 113,000 acre feet, or more than 182,000,000 cubic yards per annum.

Imperial Valley

Originally the Gulf of California extended approximately 200 miles north of its present shores and 100 miles north of the present Mexican boundaries into southeastern California. The Colorado River, heavily laden with the silt brought from the upper regions, has, during the centuries, deposited its burden as it entered the Gulf from the east side, gradually forming a huge delta which, working its way across, finally separated entirely the upper portion from the Gulf proper. After the separation and due to the silt formation, the river swung to and fro, flowing first into the Gulf and then into the inland lake. The long intervals of time between, however, permitted the removal of the water by evaporation until finally a basin-like valley, now known as the Imperial Valley, some 40 miles in width and 80 miles in length, with its lowest point approximately 250 feet below sea level, is the result.

Though, due to the very meagre annual rainfall, this valley was one of the worst sections of desert traversed by the early pioneers, an ample water supply will make possible the irrigation of approximately a million acres of land unexcelled in richness within the United States.

Some 25 years ago a group of men with keen vision and faith in their convictions sensed the possibilities of this land, and after tremendous effort were successful in constructing the necessary works to bring water from the Colorado River to irrigate a part of the Imperial Valley. Today the results of such foresight and enterprise are shown by 462,000 acres of land reclaimed and under cultivation, a population of over 60,000 people with several well-built cities and an assessed property valuation of over $100,000,000.

Other Reclamation Projects

On the Arizona side, directly east of the Imperial Valley, is an equally fertile section of approximately 110,000 acres known as the Yuma Valley, and in addition, at various locations on both sides of the Lower River, are several projects including the Parker Project, 110,000 acres; the Palo Verde Valley, 78,600 acres; the Mohave Valley, 34,000 acres and the Cibola Valley with 16,000 acres; all of which, immediately adjacent to the river banks, have been formed by the deposition of silt. This land is extremely fertile and in a climate productive to the best form of agricultural development.

Flood Menace and Damage

The achievement in reclaiming the Imperial Valley has not been lightly won. The Colorado River, flowing along the eastern rim of the valley, has deposited a large portion of its silt along its bed, raising the level nearly a foot per annum until the river now flows on top of a silt ridge 300 feet above the lowest point of the valley.

Protective works of the levee type have been constructed at great expense to prevent the waters of the Colorado from returning to the valley. These have proved inadequate, and in 1905 and 1906 the river breaking through flowed for 18 months into the valley, forming the present Salton Sea, and in addition not only destroyed a large amount of property and land but entailed an expense of some $4,000,000 before it was again controlled and confined to its banks. Prior to and including the year 1924, more than $10,000,000 was expended for flood protection alone, and this expense continues. Each year the people of the valley are called upon to spend large sums of money for the maintenance and repair, and also the raising and extension of these levees. In addition to these expenses the annual cost for the removal of silt from their irrigating ditches and from their lands is approximately $1,350,000.

Finally the silt-formed delta has reached a condition whereby the river is now filling the last available depression into which it is possible to be guided by the hand of man. When this depression is filled, estimated by various authorities from 5 to 15 years, it may be practically impossible to withhold the river against turning and again flowing into the Imperial Valley, destroying by flood the almost superhuman efforts of the past 25 years. A destruction differing from that of the

Mississippi floods in that the only way that the water could be removed would be by evaporation, necessarily taking many years for its accomplishment.

Both the Yuma and Palo Verde Projects have been also subjected to disastrous floods within the past 20 years, causing great damage to property and crops on each occasion, the last one causing over $2,000,000 damage to the Palo Verde Project alone. The Mohave Project, after large amounts had been expended for levees, was forced to abandon further work due to their inability to provide protection from the flood menace.

Mexican Situation

During the early development of the Imperial Valley the finances were limited. In order to reduce the first cost an agreement was entered into with the Republic of Mexico, whereby a canal could be constructed with its diversion within the United States but immediately passing for a distance of 60 miles through the Republic of Mexico before again returning across the boundary to the lands of the Imperial Valley. As the price for this concession by the Mexican Government, the American farmers were forced to agree that Mexican lands would be entitled to one-half the flow through the canal. With the present area under direct irrigation of 462,000 acres in the Imperial Valley and 217,000 acres in Mexico, the low flow of the river is inadequate for all. This was clearly shown in 1924, when the total flow in the river was below 1300 second feet and for 76 days every drop of water in the river was diverted. It is also apparent that under such conditions, if Mexico insists on her present plans of development and one-half of the water, then for each additional acre placed under cultivation in Mexico an acre in the Imperial Valley must return to desert conditions unless there is storage and regulation of the flood waters.

The extremely serious situation of Imperial Valley may be appreciated by pointing out that this canal forms the only possible source of water for not only irrigation but for domestic use, and if interfered with for only a week it would mean not only financial ruin by destruction of crops, but the entire population and all live stock would have to be removed from the valley.

Domestic Water

The phenomenal growth of Los Angeles and the coastal cities of Southern California since the war has resulted in such an increase in the consumption of water for domestic and commercial purposes that the limit of the available supply is dangerously close to complete absorption.

In 1906 the city of Los Angeles began construction of an aqueduct to bring water from the Sierra Nevada Mountains 250 miles away for the use of its inhabitants. At that time the population of the city was approximately 160,000. It was estimated that the aqueduct would supply a sufficient quantity of water for a population of 2,000,000 and at the rate of growth it would certainly last for many years before this population was reached. Today with a population of over 1,200,000 and with the rapid growth continuing, urgent haste is necessary in obtaining an additional source of supply. This same condition, due to the rapid increase in population, exists in the surrounding communities and cities now dependent upon the small streams available and the percolation of flood waters into the underground gravel, a supply rapidly approaching complete utilization.

With this urgent necessity in mind, these cities, including Los Angeles, have made careful investigation as to the available sources of additional supply and find that the Colorado River furnishes the only source of sufficient magnitude to meet their necessities for an appreciable length of time. Filings have been made for the appropriation of 1500 second feet for domestic use in the cities above mentioned, and the formation of a metropolitan water district to finance the proposed $150,000,000 aqueduct project for carrying this water from the Colorado to the coastal plain cities has been formed. The city of Los Angeles has voted and expended nearly $2,000,000 on preliminary engineering rights of way.

Government Recognizes Necessity

Due to the magnitude of the project necessary to furnish relief from the flood menace and to provide the necessary storage and regulation of the flood waters as well as the large quantity of silt, appeal was made to the United States Government for assistance. That the problem demanded solution and immediate action by the Government was very clearly stated by Dr. Hubert Work, Secretary of the Interior, in his report to the Committee on Irrigation and Reclamation of the House of Representatives, on March 17, 1924, when he said:

> The Colorado River has been under observation, survey and study, and the subject of reports to Congress since the close of the Civil War. More than $350,000 have been expended by the Bureau of Reclamation since the Kinkaid Act of May 18, 1920. More than $2,000,000 have been expended by other agencies of the Government. The time has arrived when the Government should decide whether it will proceed to convert this natural menace into a national resource.

Government Plans for Relief

As indicated by the Secretary of the Interior in his report referred to above, the United States Government has expended large sums of money in an investigation looking toward the best solution of the problems comprising flood and silt control, storage and regulation of flood waters for irrigation and domestic uses. The first and preliminary report made public was the so-called Fall-Davis Report published as Senate Document 142, 67th Congress, 2nd Session. The latest and most comprehensive report is the Weymouth Report to the Secretary of the Interior dated February, 1924, together with the supplemental report of June, 1924. This report incorporates a careful analysis and study of the resources and possible development of the entire river below the junction of the Green and the Colorado River.

Complete development, under the comprehensive plan thus determined, of which the proposed Boulder Canyon Project is a part, will result in the minimum amount of water lost by evaporation from the storage reservoirs and the maximum amount of hydroelectric power equaling 6,800,000 horsepower of peak capacity. The report shows further, that the first logical step in the program and the one providing the maximum amount of relief in the immediate crisis would be the building of the proposed dam in the main stream of the Colorado at the lower site of the so-called Boulder Canyon Storage Project, approximately 30 miles east of Las Vegas, Nevada; the river at this point forming the boundary line between the states of Arizona and Nevada.

CHARACTER OF PROJECT

General Description

The Boulder Canyon storage location furnishes one of the most remarkable dam sites in the United States as the walls rise abruptly to a height of approximately 1000 feet, forming a narrow gorge. The foundation rock is admirably suited in every way for the construction of such a structure. It also provides a natural reservoir site which could, if necessity should demand it at any future time, provide a storage capacity of perhaps twice that now contemplated. The present plan of the Reclamation Service calls for a dam 550 feet in height above the low water level of the river, which would impound in the storage reservoir approximately 26,000,000 acre feet of water. With bed rock of approximately 110 feet below the present low water of the river, the total height of the dam structure will be 660 feet, a material increase over the highest dam now in existence. The tentative design as prepared calls for a structure of the gravity type arched up stream, a length at the foundation of 275 feet at the present low water line and across the top of the dam of 1100 feet.

Although such a structure is a new adventure in magnitude of design, it is well to remember that the engineers of the Reclamation Service who will build the dam under Government plans have also designed and built not only more dams than any other organization in the United States but practically all of the larger ones. Careful investigation has been made as to the type of structure and estimates prepared on the cost for both rock fill and concrete designs.

Adequate spillways will be provided by means of tunnels through the rock wall on the Arizona side to a small side canyon which enters the river a short distance below the dam. The cost of a 550-foot dam complete is estimated to be $41,500,000 exclusive of interest during construction.

Hydro-Electric Power

The United States Reclamation Service, in its early conceptions of the plan for the proposed Boulder Canyon Project, realized that there would be incident to the Project an opportunity for the development of a large block of hydro-electric power. Investigations as to probable power market were made and resulted in ample assurance that conditions were such that there would be a market for the power and that the revenue from that source would be sufficient to repay the Federal Government for its total investment in the Project, over a period of years, with interest, and also the cost of operation and maintenance.

Accordingly, the Secretary of the Interior has caused to be written into the proposed legislation alternative methods of providing for revenue from the power. One plan contemplates that the Government itself build a power plant of approximately one million horsepower installed capacity. The average or firm horsepower, if generated continuously day and night through the year, would be approximately 550,000 horsepower, hence a one million horsepower generating plant would carry peak loads during the hours of heavy demand such that the average load would be 55 per cent of the peak; that is, the power would be developed on a 55 per cent load factor.

The investigations and reports referred to estimate the cost of the power plant to be $31,500,000, exclusive of interest during construction, and it is proposed that the Government sell the power at the switchboard of the power plant at a price that will cover the cost of operation and maintenance and the repayment to the Government of the cost of the storage and power project combined over a period of years, with interest. The plan, therefore, contemplates that the Federal Government would loan its credit but be fully reimbursed for its investment, with interest, and the proposed legislation requires the Secretary of the Interior to enter into firm contracts for power, sufficient to provide complete reimbursement to the Federal Government, before the expenditure of any money for the construction of the project.

Alternative Power Program

In order that the Secretary of the Interior, who would be directly responsible for the financial success of the undertaking, might be assured of every assistance in the working out of such a plan, the proposed legislation contemplates that he may, in lieu of selling the power at the switchboard, lease units in the Government constructed plant, or at his discretion lease the right to develop power by means of the water discharged from the dam to applicants who would then build, under Government supervision, their own plants for the development of hydro-electric power, thus relieving the Government of this portion of the investment. Proceeds from the sale of power rights would take the place of revenue from power and be used in the amortization of the cost of the dam structure and project.

All-American Canal

In addition to constructing the above-mentioned project at Boulder Canyon, and in order to relieve the Imperial Valley from its present dependence on Mexico, the plan contemplates the construction of a so-called All-American Canal, approximately 60 miles in length, which would lie entirely within the United States. In the plans for this canal it is proposed to move the point of diversion to the present Laguna Dam, some 12 miles above the city of Yuma. At the time this dam was constructed the Imperial Valley entered into a contract with the United States Government and agreed to pay and is paying for the privilege of this diversion $1,600,000 out of a total cost for the dam of $2,180,000. This will also enable the water to be taken out at a much higher level, making possible the irrigation at some future time of some 500,000 acres of additional land lying in the Imperial and Coachella Valleys.

A board appointed under an agreement between the Secretary of the Interior and the Board of Directors of the Imperial Irrigation District, composed of Dr. Elwood Mead, now Commissioner of Reclamation, C. E. Grunsky, consulting engineer of national reputation, and W. W. Schlecht, Engineer of the Reclamation Service, made a complete report including estimate on the cost of such canal, and also reported favorably as to its feasibility and desirability. In addition to this board, engineers of high standing have, with practical unanimity, after thorough investigation, endorsed the plan for such a canal.

The estimated cost of the all-American Canal is $31,000,000, exclusive of interest during construction. Although this appears large, the cost per acre for all construction charges as determined by the Secretary of the Interior including the present bonded indebtedness of the Imperial Irrigation District of $25.50 will be as follows:

Imperial Irrigation District..........	$66.00
New lands under All-American Canal	90.40

When these figures are contrasted with the average construction costs of present reclamation projects they show the reasonableness and feasibility of such a project from the cost standpoint.

While the urgency of this canal cannot be questioned, yet it must be considered that it is wholly infeasible without control of flood waters and the storage reservoir for the removal of silt and the regulation of flood waters according to an irrigation program.

The Secretary of the Interior at the request of Congress submitted a proposed plan of development financed through the sale of the hydro-electric power, including a 550-foot dam and a one million horsepower plant, together with the All-American Canal, as follows:

As to cost for:	
26,000,000 acre foot reservoir	$41,500,000
1,000,000 horse power development	31,500,000
All-American Canal	31,000,000
Interest during construction, 5 yrs. @ 4%	21,000,000
Total	$125,000,000
As to revenues—annual operation:	
Sale 3.6 billion kilowatt hours @ 3/10c	$10,800,000
Storage and delivery of water for irrigation and domestic purposes	1,500,000
Total	$12,300,000
As to annual fixed charges for operation and maintenance, storage and power	$700,000
Operation and maintenance, All-American Canal	500,000
Interest on $125,000,000 @ 4%	5,000,000
Total	$6,200,000
Estimated annual surplus or sufficient to repay the entire cost in 25 years	$6,100,000

From the above it is apparent that the proposed plan is absolutely feasible from a financial point of view.

SIGNIFICANCE TO THE SOUTHWEST

Agriculture

The controlling of the floods and the storage and regulation of these waters will permit of the ultimate irrigation of lands in the states of Nevada, Arizona and California totaling approximately 1,750,000 acres including lands already under irrigation.

As the available water supply of Southern California for irrigation purposes is practically exhausted, and with the rapidly growing population, it is evident that these additional lands will be required in the future along with a growing demand for farm products from other sections to feed the rapidly growing market of the Pacific Coast as well as the local markets in the states of Arizona and Nevada.

Manufacture

One of the most potent factors in the building up of an industrial community, and next to its supply of domestic water, is the ability to furnish its institutions cheap electric power. The construction of the dam will make available 1,000,000 horsepower of cheap hydro-electric power to the industrial markets of Arizona, Nevada and California, with its natural impetus toward increasing the production of present plants and the attraction of additional industries to the communities. Experience shows that as our population and industrial activity along our special lines increase our demand for food and manufactured articles from other parts of the country increases in even greater proportion.

Domestic Water

The storage of the flood waters and the removal of silt by the reservoir will furnish a supply of portable water for the cities of Southern California, and without which their growth must, at the present rate of increase, abruptly cease. It is, therefore, imperative that if the Southwest is to grow, additional water must be procured and the only available source is the Colorado River.

SIGNIFICANCE TO THE COUNTRY AS A WHOLE

The construction of the Boulder Canyon Project will have a decided bearing and significance to the country at large as it will necessarily call for large quantities of construction material and equipment, practically all of which must be at present supplied from eastern markets. Large blocks of cheap power, permitting the growth of industry in the Southwest, will add materially to the shipment of commodities both raw and finished between the east and west.

As the land is placed under cultivation, in addition to supplying the local markets of the Southwest, due to the practically all-year growing season, it would be possible to ship to the eastern markets produce and staple vegetables at a time when they can be obtained from no other source in sufficient quantity except from foreign countries.

The construction of the All-American Canal and regulation by the storage reservoir will unquestionably stop Mexican interests from adding materially to land they now have under cultivation, which is practically all utilized in the growing of cotton. This cotton is grown in Mexico not only by cheap foreign labor but enters the American market to compete with American grown cotton. While it has been feared that Imperial Valley lands would be used for the growing of cotton it is found by experience that they are better suited both climatically and financially to the growing of vegetables and similar commodities, and as pointed out these will either be used locally or enter the eastern market at a time when eastern farmers could not possibly supply them, and, therefore, they will not interfere with the present farming industry. The development of new lands by irrigation necessarily will be slow and will not equal an equivalent of the growing markets of this section.

Problems of the Colorado River

Relative Advantages of the Boulder Site

By Arthur P. Davis

Chief Engineer and General Manager, East Bay Municipality District, Oakland, California

THE Colorado River is one of the large and important rivers of this country, but has a very fluctuating discharge, due to changing seasons and changing years. If completely regulated its magnitude is sufficient to furnish an ample domestic supply of water to all the inhabitants of the United States, and a considerable margin over. The low water flow of the river during the latter part of summer and autumn, is all utilized in irrigation, and the development has proceeded to a point where in the drier years there is a serious shortage of water during September and October for lands already under cultivation; but the spring and early summer furnish vast quantities of flood water that not only run to waste, but do great damage to lands along the banks of the river, and especially in the Imperial Valley, which being an interior basin, if flooded, would be permanently destroyed. The imminence of such destruction is the occasion of the urgency of this problem.

The problem of changing the Colorado River from a natural peril to a national asset, is mainly a problem of water storage. Reservoir sites of large capacity have been examined and found feasible on the upper tributaries of the Colorado, and while these can partially regulate these tributaries, and assist in their development, they are not large enough nor properly located for complete control and development of the river. The bulk of the storage capacity must be provided within or below the canyon region where it can intercept most of the entire flow of the basin. Otherwise, the waters will be largely wasted as at present, and continue to be a menace to the valleys on the lower river, which will probably be destroyed if regulation is not accomplished in the near future.

The only site of sufficient capacity and properly located to accomplish all these results is at Boulder Canyon, where it is feasible to construct a reservoir to any capacity from 20,000,000 to 45,000,000 acre feet, and while completely regulating the river at that point, at the same time will develop sufficient power to pay for itself. Aside from its paramount virtues in water regulation for irrigation and flood protection there is no other plan of development which will produce power so cheaply as a large reservoir in Boulder Canyon such as proposed.

Active Opposition

It was first vigorously asserted by the opponents of Boulder Canyon Reservoir that 600,000 horse power developed at Boulder Canyon could not be absorbed by the available market for power for twenty years, and that in the meantime the interest charges would accumulate to such an extent as to make the development prohibitive. Finally the matter was referred to Mr. L. S. Ready and Mr. H. G. Butler, who made a thorough examination of the subject, and proved that if the Boulder Canyon power were immediately provided, the power developed would be absorbed within three or four years after it could be produced.

OTHER SCHEMES FATAL TO CHEAP POWER

Notwithstanding this authoritative finding, the opponents are still expressing doubts as to the wisdom of so large a development and repeating their former recommendations that the river should be developed by a series of small dams. As represented by actual schemes of construction submitted, five dams are proposed of heights, respectively 158 feet, 163, 194, 209, 223 and 225 feet, in portions of the canyon where much larger development would be far more economical. Such development would be fatal to cheap power.

In general, the power developed by means of a low dam in the Colorado Canyon is far more expensive per unit than the power produced by a high dam. In either case, the floods of the river must be controlled to permit the excavation of foundations, which are everywhere deep. These control works cost as much for a low dam as for a high dam. The same is true of the railroad which must be built to convey materials and machinery to the site, which is in any case, a heavy expense. This also is largely true of the great construction plant; while the production of power by a low dam would be less in proportion to the height of dam, due to the better regulating effect of the water by the wider pond produced by the high dam, and the fact that each reservoir must be provided with a margin for the rise and fall of floods, above its top without interfering with the next development above.

POWER 30 PER CENT CHEAPER AT BOULDER

Careful estimates of cost, based upon extensive surveys at the Boulder Canyon site, show that a dam 555 feet high, proposed, will develop power nearly 30 per cent cheaper per unit than a dam 50 feet lower.

A still lower dam would be similarly more expensive per unit of power produced and in varying degrees the same principle applies to the development of any power site in the canyon region within the limits of feasible height of construction. Under such a plan power development on the Colorado would be no longer a menace to the investments in future power sites in the Sierras, for it would make the cost of Boulder Canyon power about as great as that produced in the Sierras, and it is such development as this that may be expected if it is turned over to private exploitation. This would largely destroy the great natural asset which the Nation owns in the power possibilities of the canyons of the Colorado.

One criticism of the Boulder Canyon plan is that a high dam would produce so large a pond that the losses by evaporation would be excessive and that the reduction of the floods to a maximum of 40,000 cubic feet per second as proposed is not necessary, but that a reduction to 80,000 would do about as well. A fair summary of the argument is that it is unwise to store this water because the reservoir would lose part of it by evaporation, and that it is better to allow the floods to continue to flow to the sea unused and to fight them on the way by means of high levees and other expensive and perilous provisions.

DAM IN MOHAVE CANYON

The same authority proposes to substitute for the Boulder Canyon storage, a reservoir in Mohave Canyon, which would have a much larger water surface and entail about 75 per cent more evaporation in proportion to water stored. It would also submerge the city of Needles, the large railroad hotel, round-house, machine shops, arge icing plants, twenty-four miles of yard track and twenty miles of double track main line, and the length of the transcontinental railroad would be ncreased about three miles. It would require the reconstruction of a similar ength of the Santa Fe Trail highway and two great bridges across the Colorado River. It would also submerge over 30,000 acres of excellent land in the Mohave Valley, susceptible of easy irrigation, after the river is controlled, which could not be replaced. It is true other areas could be irrigated with the same water, but these other areas can only be reached by expensive canals, long tunnels and high pumping lifts, which would cost $200 per acre, or more, for construction, and incur prohibitive prices for operation and maintenance. Such enterprises are not feasible now, and may never be, and while it is wise not to prejudice their future possibilities, the argument that they justify the destruction of rich bottom land along the river is untenable and destructive of natural resources.

The dam in Mohave Canyon that would entail all of this destruction would produce very little power because of lack of head. It would be the most expensive power site in the Colorado Canyon that is seriously proposed by anybody, being more than double the cost per horse power of the proposed development in Boulder Canyon, besides its enormous evaporation losses. Its construction would be a signal victory for anyone opposed to the development of cheap power on the Colorado.

GLENN CANYON PROJECT IMPRACTICABLE

The Boulder Canyon development has been antagonized by a proposition to build a large reservoir in Glenn Canyon in northeastern Arizona, nearly twice as far from the principal markets and much more expensive in construction. Estimates of relative costs show that the development of power in Glenn Canyon would be nearly twice as expensive per unit as in Boulder Canyon, and the cost of transmission to points of use would be fully twice as great. The Glenn Canyon Reservoir would not solve the flood control problem, because it would leave uncontrolled about 50,000 square miles of mountainous drainage between Glenn Canyon and Boulder Canyon, which would leave the flood menace very dangerous. The power produced, while much more expensive, would be less reliable, owing to the enormous length of transmission line through country remote from construction and maintenance facilities.

SALT DEPOSITS

One of the objections heard is the allegation that the Boulder Canyon Reservoir would be rendered unfit for irrigation or domestic use by reason of salt deposits that occur therein. This question was thoroughly investigated by an eminent geologist of the United States Geological Survey, who reported that the quantity of salt, as compared with the volume of water, was negligible, and that in any event a brief period of solution would so undermine the overlying earth that it would cave in and cover up the deposits before any injurious amount could be dissolved. All competent experts who have examined this subject are agreed with Professor Ransom in the above conclusions and their opinions have been duly published and made available to the public.

One after another of the objections to the Boulder Canyon development have been met and refuted, but regularly they are reiterated or new objections are invented. It is hardly possible that the ingenuity of the objectors has been entirely exhausted, and the interests involved are too great to allow us to expect universal acquiescence in the plan proposed.

What the Boulder Dam Project Means to California and to the Nation

By Clyde L. Seavey

Member of the California State Railroad Commission

OUT of many years of investigation by responsible Federal agencies and as a result of probably the most exhaustive course of hearings before Congressional Committees ever accorded any work of internal improvement, the so-called Boulder Dam Project for a development of the lower Colorado River has taken definite form. It contemplates the construction by the Federal Government of a great dam on the Colorado where that river forms the boundary line between the states of Arizona and Nevada and where there is not only a remarkably fine site for a dam but where there is also an exceptionally advantageous reservoir site. Under the plans for this development the dam will be 550 feet in height and will create a reservoir with a capacity of 26,000,000 acre feet. The estimated cost of the dam is $41,000,000, which means a cost per acre foot of storage capacity of but $1.58.

The project also embraces the construction of what is termed "The All-American Canal," being a canal running from the river to the Imperial Valley in California and located entirely to the north of the international boundary line between Mexico and the United States. The estimated cost of this canal is $31,000,000. As this estimate was based upon price levels existing nearly ten years ago and was made before the advent of improved methods of excavating on a large scale, it may safely be said that the cost of this portion of the project will be substantially less than the estimated figure.

Why the Development

This development is a unified development and is intended to subserve a variety of purposes with the minimum of cost.

To understand these and the reasons why the development has taken the form it has, requires a general understanding of the characteristics of the Colorado River and of the Imperial Valley.

The river is one of great fluctuation in flow, both annual and seasonal. Sometimes it discharges as high as 25,000,000 acre feet of water in a single year. The next year its total discharge may be as low as 9,000,000 acre feet. The seasonal variation in rate of flow is even more pronounced, ranging from 200,000 cubic feet per second, when in flood, to as low as 1250 cubic feet during the low water season.

The river rises in the high mountains of Wyoming and Colorado. Its mouth is the Gulf of California. Melting snow and rainfall from the mountain ranges are the principal sources of the river's run-off. The lower portion of the Colorado River Basin is made up of hot arid plains of low altitude, broken by short mountain groups. The central portion consists of a high rocky plateau, through which the river flows in a series of deep and narrow gorges.

Centuries ago what is now the Imperial Valley was a portion of the northern end of the Gulf of California. The river, as it runs through the canyon region, picks up a tremendous amount of silt or sediment. In volume, this amounts to over 100,000 acre feet each year. Gradually the deposit of this sediment built a delta across the Gulf of California. There was thus left a great inland sea which was gradually unwatered by the slow process of evaporation. In this great bowl in the desert there has been built up an irrigated area of over 450,000 acres, populated by some 60,000 people and known as Imperial Valley. This valley actually lies from 250 to 300 feet below the channel of the Colorado River. The river runs along the rim of the bowl, until it finds its way into the Gulf.

This brief statement of the existing physical conditions indicates a flood danger to the Imperial Valley region, the seriousness of which cannot be overestimated. In 1905 the Colorado River did break from its channel along the delta and flowed into Imperial Valley. By almost superhuman efforts the river was restored to its old channel and directed to the Gulf of California. Just when another break will occur no one knows. It is known that year by year as the river piles up its volume of silt along its varying channels across the delta the imminence of the break becomes greater and greater.

To all of the Government officials who have investigated the situation thus adverted to, it has been obvious that the solution of the flood problem lay in the construction of a regulating dam up the river where there might be found both an appropriate site for a dam and an appropriate site for a reservoir. Such a dam would intercept the flood waters of the river and permit of their being released at times when the channel could safely carry them to the Gulf of California. Perhaps even more important than this was the fact that such a dam would intercept the silt of the river and thus prevent the gradual filling up of any natural depressions across the delta by which the water of the river may be conducted to the Gulf.

Just as it was obvious that the construction of such a dam furnished the remedy for the flood menace to Imperial Valley, just so it was apparent that the expense of such a dam was beyond the ability of the Imperial Valley to undertake and was probably of such magnitude that the Congress of the United States would long hesitate to authorize it as a direct and unreimbursible outlay.

Out of this situation developed the idea of a unified development by which the dam and reservoir would be of sufficient size and capacity not only to provide for flood control but also for future irrigation requirements of the lower Colorado River Basin and to make possible a power development, thus providing sources for a full reimbursement to the government of the cost sustained.

After the plan of such a unified development had assumed rather definite form a new interest arose of far-reaching public importance and one which made the development an even sounder one in its financial aspect than it at first appeared.

Since the census of 1920 the city of Los Angeles and the other cities of the coastal plain of southern California have experienced a tremendous growth in population. At the same time these cities experienced a period of dry years, which demonstrated the inadequacy of their present sources of domestic water supply. These two circumstances coming together caused this section, having a population of probably not less than two millions of people, to awaken to the imperative necessity of supplementing its existing sources of domestic water supply. Investigations indicated the only practical source of such an additional supply was the Colorado River. To secure such a supply involved not only the building of a great aqueduct over two hundred miles in length from the Colorado River to the coast and the pumping of water to an elevation of over twelve hundred feet, but it also necessitated large storage in the Colorado River in order that there might be sufficient water to supply the needs of the territory tributary to the river and the needs of the coastal plain cities for domestic water, and also to remove certain technical and engineering difficulties in the way of desilting the water to render it susceptible to being pumped the great elevation necessary and its use for domestic purposes. It happened that the Boulder Dam plan of development fitted in ideally with this plan of securing a domestic water supply for the coastal cities. The need of a large amount of hydroelectric power to pump this water over the mountain ranges to the cities on the coast greatly broadened the market available to absorb any power generated at the dam and removed all reasonable doubts as to there being an available market to absorb any power which might be developed.

At the present time the Imperial Valley secures its sole supply of domestic and irrigation water by means of a canal which starts at the Colorado River a few miles north of the international boundary line and then proceeds in a rough semicircle for about sixty miles through the Republic of Mexico before reëntering the valley and delivering water to the lands on the American side of the international line. There are some 800,000 acres of land in Mexico tributary to this canal, owned almost entirely by American capitalists, which has been developing more rapidly than has the Imperial Valley and under circumstances both unfair and detrimental to the interests of irrigationists in the United States. The very existence of such a canal extending through a foreign country is conducive to international inharmony and trouble. Furthermore, the rapidly increasing draft upon the water carried by this canal for irrigation in Mexico coming on top of increased irrigation uses in Colorado, Utah and Wyoming frequently leaves the Imperial Valley subject to serious water shortages. Provision of large storage on the Colorado River in the United States, with nothing more, would leave this great area of land in Mexico as the chief beneficiary of the development because of the increased water supply which would come from river regulation and which increased supply would be available to Mexican land before reaching the Imperial Valley. The All-American Canal not only will solve a vexatious international situation but will relieve Imperial Valley from danger of water shortage and, together with the control of the release of water from the dam and reservoir, will give the United States strategic control of the waters of the Colorado River so that Mexican interests will not be able, against the will of the United States, to lay the foundations of claims to an undue proportion of the waters of the river.

That this development means a great deal to California goes without saying. But what it means to California it means in a greater or less degree to Arizona and Nevada.

It means that the Imperial Valley, in southern California, a valley made up of a sturdy pioneer stock of Americans, will be freed from the ever present menace of destruction by flood.

Proportionally, it means as much to the people of Yuma, Arizona, where there is a National Reclamation project, because this section, too, is subject to the menace of the Colorado River floods.

It means that the Imperial Valley will be freed from its present intolerable condition of securing its sole supply of water from a canal running through a foreign country.

It means, too, that this valley will no longer be faced with the danger of a water shortage—a danger hardly less serious than that of destruction by flood, since in that desert country nothing can live without water.

It means that the flood and waste waters of the river will be conserved and made available for future irrigation development in California, Arizona and Nevada. While plans for such development are more advanced in California than in the other states, relatively the advantage to the other states will be greater.

It means that there will be made available a large block of dependable hydro-electric power urgently needed in California but which relatively will be of greater advantage to the states of Arizona and Nevada, because these states, generally speaking, are not in as advantageous a position as is California in respect to steam power.

It will open the way to the coastal plain cities of southern California, securing an additional and imperatively needed domestic water supply.

Under the plan of development, which contemplates the Government *either building power plants at the dam and selling power at the switchboard or leasing the fall of the water to applicants for the generation of power*, danger of a monopolization of the power resources of the lower Colorado River is forever safeguarded against, as the whole scheme contemplates that the power or power privileges will be divided amongst various applicants. A monopolization of the power of the lower Colorado would mean that the agency securing it would be in a position of dominance in the industrial and political life of the Southwest.

NATIONAL ADVANTAGES

While the Boulder Canyon development will be of tremendous benefit to California, Arizona and Nevada, it is a mistake to think of it as a matter of merely local consequence. Works of internal improvement must be accomplished in steps, and each step is usually of more immediate importance to the section in proximity to it than to other sections of the country. The taking over of the Cape Cod Canal by the Federal Government was of more immediate consequence to portions of New England than to the South or Middle West or the Pacific Coast. Improvement of the Mississippi has its immediate beneficial effect upon regions lying in the valley of that great river. The proposed St. Lawrence development affects one section of the country more directly than another.

The nation as a whole is interested in this development because, among other things, it solves a vexatious international situation. It is perfectly obvious that sooner or later the Colorado River will be developed. By reason of the fact that the canal serving Imperial Valley passes through Mexico, unless this development is shaped on sound lines Mexican lands will be the chief beneficiaries and claims and rights will be created which may prove in the future extremely detrimental to American interests. The plan of the Boulder Dam development will put the United States in control of the waters of an American river and insure that waters conserved by the development may be used in this country rather than in a foreign country.

This project is the first step in the development of a great river having tremendous possibilities. If developed in the public interest and on sound lines it has tremendous potentialities for good to the Southwest. The consummation of the Boulder Dam project means that the river will be developed in the public interest. For example, it insures the use of the waters for river regulation and irrigation in preference to use for power generation. The importance of this in a section dependent upon water for its agricultural growth can hardly be overestimated.

All Costs to be Refunded

Perhaps the most interesting feature of the development lies in the financial scheme upon which it is built. This represents a distinct departure from anything heretofore attempted. Thus far in the history of this country Federal internal improvements have represented either an unreimbursed outlay from the National Treasury or an advance of funds to be reimbursed without interest, as in the case of reclamation projects. Here there is to be a complete reimbursement with interest. Even more significant than this is the unusual requirement that before any work is undertaken or any expenditure made the development must be completely underwritten by its beneficiaries. Firm contracts for the storage and delivery of water for irrigation and for domestic use and for the purchase of power and power privileges must be secured by the Government in advance of construction. As various responsible agencies are eager to contract for water and for power, this development, if authorized, will be of assured and demonstrated financial integrity.

The Objectors

Unfortunately, a consideration on its merits of this great work of internal improvement is liable to be prevented by the bitter struggle which is now centering about it. Private power interests, desirous of securing for themselves a complete monopolization of the tremendous hydro-electric possibilities of the lower Colorado River, unhampered by obligations respecting river regulation and use of water for irrigation, have launched a determined attack upon this development because it means that power will not be monopolized and that the waters of the river are first dedicated to river regulation and irrigation. Men influential in the business and political life of the Southwest who own or control vast areas of land in Mexico are bitterly opposed to this development, because it stands in the way of their securing special advantage to their great holdings. Each of these interests would have the Government make an unreimbursed outlay of some $25,000,000 for a low flood control dam, for such a dam would leave the hydro-electric resources of the river open to acquisition by the power interests and would redound to the benefit of owners of land in Mexico, as it would eliminate an all-American canal and in a practical way insure increased deliveries of water at periods when water is now approaching the point of shortage.

On top of this the situation has been further complicated by a resuscitation by certain of the intermountain states of the old doctrine of states' rights, a doctrine which has been conveniently forgotten by them during the long period when they were securing extensive assistance from the Federal Government in reclamation projects. These states are invoking this doctrine as a ground or pretext for claiming large revenue from the development of the river, claims which, if recognized, would render the whole project unsound from a financial standpoint.

The next few months will witness a bitter and dramatic struggle over this development, the outcome of which will afford an interesting indication of the ability or inability of the American people to develop one of its great natural resources in the public interest.

My Objections to the Boulder Dam Project

By Hon. E. O. Leatherwood
Congressman, Utah

I HAVE been asked to state why I am opposed to the Boulder Canyon Dam project as it is proposed to be authorized in what is known as the Swing-Johnson Bill before the Congress of the United States. I can answer the question in one sentence. It is dishonest, dangerous, unsound and unnecessary legislation.

It is dishonest because it is masquerading under false colors. It purports to be a flood control and reclamation project but is, in fact, a government-ownership power project, which only incidentally provides some, but inadequate, flood control, and which may, if agricultural conditions improve, at some future time result in some irrigation development.

It is dangerous in two large aspects: first, because it subverts the relation between the national and state governments in that it would subordinate to national control the state control over the waters of the streams within the borders of the states themselves, and it would establish the precedent for federal bureaucratic control over vital industrial resources of the states; second, it would establish the dangerous precedent that the federal government may, in carrying out a legitimate function, undertake a business enterprise having no relation to its legitimate function except that the business enterprise is undertaken in the hope that profits therefrom will enable the federal government to pay the expense of the legitimate function.

It is unsound in the legal theory upon which it is based, namely, that the federal government may, under the guise of doing one thing, do an entirely different thing. It is further unsound in its economic, engineering and financial bases. It represents a political solution of what is essentially an engineering problem.

It is unnecessary because the regulation of the flow of the Colorado River in its lower basin calls for an expenditure of no such magnitude, nor for the risk of the taxpayer's money in an expenditure for the production of electric power for which there is no adequate market either now or in a practical future period.

Let us proceed to discuss the proof of the foregoing assertions.

The Boulder Canyon Dam Bill Is Dishonest

This bill has been repeatedly represented by its authors on the floor of both Houses of Congress, as well as by that powerful chain of newspapers which propagandizes on its behalf, as a flood control bill for the protection of the Imperial Valley in California. The danger and distress of the Imperial Valley have been described in harrowing terms, and it is on this appeal to country-wide human sympathy for sixty thousand lives and thousands of homes in danger from the floods of the "torrential Colorado" that chief reliance has been placed to arouse popular support. The danger is represented as being an imminent one calling for immediate preventive action.

In the face of these assertions as to flood danger, the following are the facts: First, there is no danger to human life involved in this flood menace, and there is, indeed, no danger to property in the ordinary understanding of danger from a flood. Whereas the ordinary river flood means the sudden inundation of large areas and the flooding out of farms and homes, the flood waters of the Colorado would, during the first few months of a flood, inundate no homes or farms in the United States, but would simply flow into the existing inland sea known as the Salton Sea and very gradually raise the level of that sea. The annual flood of the Colorado is caused by the melting snows and does not last for a longer period than three months. At the end of that period the river subsides to a flow at which, through the present equipment for fighting it, it could very probably be again controlled and rediverted from its flow into the Salton Sea. Three months' or even a year's flow of the Colorado into the Salton Sea would cause no substantial damage to property. It is, therefore, rank misrepresentation to picture the flood danger to Imperial Valley as the ordinarily understood flood danger from other rivers in the country.

A dam which will also provide the necessary storage for silt and for water for irrigation purposes can be constructed at a cost of not to exceed $15,000,000. Flood control alone, without storage, that is, through channel dredging and levee construction, can be provided at a cost not to exceed $6,000,000. The cost of the project to be authorized in the present Boulder Canyon Dam Bill is estimated at $125,000,000, and its probable cost will be double that amount. The storage required for flood control is estimated at from 4,000,000 to 8,000,000 acre feet. The storage provided for in this project is 26,000,000 acre feet. Here, then, we have a bill masquerading as a flood control bill in which nine-tenths of the expenditure and approximately 75 per cent of the storage are for purposes wholly other than flood control! To represent this as a flood control bill is as to honesty and accuracy on a par with the representation that the annual appropriation of the Interior Department is for the maintenance of national parks, because a fraction of the appropriation goes for that purpose.

It is not primarily either a flood control or irrigation project. These facts were pointed out as long ago as March, 1925, by the three Cabinet officers who passed upon the project and condemned it. I refer to Secretaries Weeks, Work and Wallace and to their letter of March 24, 1925.

We do not, however, have to rely upon the statements of opponents to establish this fact. As recently as September 29, 1927, in the leading press organ for the Boulder Dam Bill, it was stated editorially:

> A compelling reason for including the power feature is the domestic water situation in Southern California. Los Angeles and twenty-seven other cities are applicants for Colorado River water. They must draw upon this in the not distant future. They stand ready to pay for it. But the only way to get it is by pumping it, and for this operation the only possible source of sufficiently cheap power is Boulder Dam.
>
> It is true a high dam is not needed for flood control. But a high dam is needed to impound a domestic water supply and to generate the power to pump it.

The mask is now off. This is not a flood control or an irrigation project. It is a power project primarily designed for furnishing power and water to the city of Los Angeles. Upon these facts I submit again that the Boulder Canyon Dam Bill is dishonest.

THE PROPOSED LEGISLATION IS DANGEROUS

When I say that this legislation is dangerous I speak advisedly. State autonomy, the right of states to control the development of economic resources within their borders, has never before in my experience been so seriously challenged as by this legislation. The threat is twofold; first, to take control over the development of the Colorado River, which river flows through seven western states; second, under the guise of carrying out a flood control project to enter into the conduct of a huge business enterprise within the states which will be subject to no state taxation or control, and to take over from the states the right to control the rates at which the manufactured product shall be sold and distributed within their borders.

With the first of these threats, that of taking over control of our western streams by the federal bureaucracy, we have been contending for more than two decades. In the face of decisions contrary to their contention by the United States Supreme Court and by other federal as well as state courts, the Bureau of Reclamation of the Department of the Interior has since its creation persistently asserted a control over the streams in the West which subordinates state authority and prohibits irrigation developments approved by state authorities from proceeding without the consent of this federal bureau. Perhaps the two outstanding bitter experiences which the western states have had in this regard with the federal bureau have been on the North Platte and the Rio Grande Rivers. In connection with the construction of the Pathfinder Dam on the North Platte and the Elephant Butte Dam on the Rio Grande, the Bureau of Reclamation caused the Secretary of the Interior to declare embargoes against developments authorized by the states on the headwaters of those rivers. The areas affected by the embargoes were ready for development, and citizens of the states were ready and eager to proceed with the developments. Delegation after delegation from the states importuned Congress and the bureau to give them relief against these embargoes, but nothing was done. The embargoes continued for a period of almost twenty-five years. One of them was then declared illegal and lifted, and the other is now ignored. Hence, without any authority from Congress, with no justification in law, and merely through the control over public lands and through a desire to exercise an arbitrary authority in an illegal manner, bureaucratic employees of the federal government have hindered and retarded the development within the states of Colorado, Wyoming, and New Mexico.

The legislation under discussion now proposes to turn over to the Bureau of Reclamation the Colorado River, and to authorize the construction by that bureau upon that river of the largest dam ever attempted in this country or in the world. In the light of experience on the Rio Grande and North Platte Rivers, those of us who live in states which must depend for most of their future development upon the water of the Colorado are keenly aware that we are here faced with a threat of future embargoes upon our state developments. An attempt was made to obviate this danger by negotiation of an agreement between the seven states in the Colorado River Basin, which, when approved by the federal government, would establish the rights of these states in the waters of the river, and at least to a reasonable degree protect against the menace with which we are now faced. That agreement, although drawn and approved by delegates from the various states, has failed of ratification by some of the states and is therefore not in effect

It is now proposed by the authors of this bill, and with the apparent approval of the Director of the Reclamation Bureau, to attempt to proceed with the building of this dam without any such compact. Relying upon the argument that this project is an interstate matter with certain international complications, it is proposed that Congress should proceed without regard to the protests of the states and without regard to whether the states are protected in their future development. So far as protection against the menace of federal bureaucracy is concerned, we are therefore in the same position as were the States of Colorado, Wyoming and New Mexico in the cases of the developments on the Rio Grande and North Platte. So much for the first menace to state autonomy.

The second danger in this legislation is even more far-reaching and fundamental than is the menace to state control over water. It is a menace to state autonomy throughout the United States. It is a menace to every citizen in the conduct of his everyday business, because in it the hand of federal bureaucracy reaches out and removes from state control a gigantic unit in industry.

To enforce appreciation of this danger I must again point out that this proposed project is not primarily a flood control project but is primarily a hydro-electric power project of the first magnitude. People generally who have given any attention to the project have been misled by its proponents into the belief that it was primarily a flood control and irrigation project which would incidentally, and only incidentally, develop as a by-product a small amount of power which should be disposed of by the government as an incident to its operation of its flood control and irrigation projects. As evidence of this there is the argument repeatedly made by the proponents that this is not the first time the government has built a power plant, because the government has built and operated power plants in connection with other reclamation projects. It is true that the government has built some fifteen small power plants in connection with irrigation projects. The total cost of these plants is slightly more than $1,400,000, and the average cost is less than $100,000. In other words, the argument is now made that because as an incident to the development of other irrigation projects the government has built some small power plants to furnish settlers on the irrigation projects with electricity—plants whose total capacity for the entire fifteen is less than 30,000 horsepower and whose total cost is approximately $1,400,000—that the government has thereby established the precedent for going into the power business by building a dam and power plant primarily for power purposes, where flood control and irrigation are the by-products, this power project to cost at least $100,000,000 and probably twice that, and to have a capacity of 1,000,000 horsepower. This single plant would have more than thirty times the total capacity of the other fifteen plants and the cost of it would be at least forty times the total cost of the other fifteen plants. Secretaries Weeks, Work and Wallace, in their letter commenting upon the Boulder Dam project, stated these facts as follows:

> While the United States has heretofore constructed power developments in connection with irrigation projects, these developments have been merely incidental to the projects, have been of a few thousand horsepower only and have been primarily for use on the projects themselves. The construction of a reservoir having a capacity of some four to eight times the needs of

irrigation and flood control and of a power development twenty times in excess of the probable needs of the irrigated lands and adjacent communities is a complete departure from former policies.

This 1,000,000 horsepower hydro-electric plant would be several times larger than the Muscle Shoals plant. Aside from the Niagara Falls installation it would be the largest single hydro-electric development in the world. The power made available would exceed by 500,000,000 kilowatt hours annually the entire amount at present consumed in the only territory where this power could find even a partial market. This gigantic stride into the power business is to be made by the United States Government with money (more than $100,000,000) raised from the taxpayers of the United States as a whole, under the specious plea that by the sale of power the money expended will eventually be repaid to the United States Treasury. And for what purpose is this huge investment and business experiment to be made? Why, say its proponents, in order to provide flood control and possible future irrigation needs in the Imperial Valley of California. In other words, in order to provide flood control and water for irrigation which, if those needs were taken care of, could be accomplished at a cost not exceeding $15,000,000, it is proposed that the government invest an additional $100,000,000 more and go into the power business in the hope that by this additional investment and over a period of fifty years or more the government will recapture all of its expenditure.

Two facts of the first importance have been insufficiently emphasized in all of the discussion of this project. These facts are, first, the size of the project and the relation between the expenditure for the legitimate function of flood control as compared with the expenditure for the proposed new activity of the government in the power business; second, that a startling departure from former government policy is proposed, in that wherever it is possible to do so, the government may go into an entirely extraneous business unconnected with government functions, in order to attempt to repay the expenditure on the legitimate function; and that the government should do this regardless of the fact that the venture into business requires an expenditure of more than ten times the amount required if the government confined itself to its legitimate function.

Let us see where this departure from former government policies would lead us. Let us suppose that the government finds it necessary to build a storage warehouse for government property at a cost of a half million dollars, and located in some city in the United States; that local interests represent that there is need for another large department store in that city and urge that the government should not spend $500,000 outright when by spending an additional $10,000,000 the whole expenditure can be recovered. Popular clamor from that district for a huge government expenditure would be aroused, and we might expect all of the pressure that that community could muster would be exerted upon Congress to induce an appropriation of $10,000,000 to build not only the warehouse but the department store. The precedent for such a measure would be very clear and well established if the Boulder Dam Bill were a law. Or again, let us suppose that the government is required to provide $1,000,000 in storage tanks for the storage of oil from a government reserve, and that investigation discloses the possibility that an oil refinery in that district would be acceptable. Again Congress would be importuned to provide $20,000,000 with which to build an oil refinery and carry on that business, and the argument would be made, using the Boulder Dam Bill as a precedent, that it is very unwise for the government to make an outright expenditure when by coupling with that expenditure a large venture into the business world the taxpayer might be saved the million dollars which would otherwise be spent for oil storage. It is true that the oil industry might object and protest against the government entering its field of business, but would not their protests be drowned in the great flood of oratory about a great oil trust which was, through selfish motives, endeavoring to prevent the conferring by the Congress of this great boon upon the common people? I can hear them now, pointing out in eloquent terms the fact that oil is a great natural resource provided by God Almighty for the benefit of the people as a whole, and that no oil trust representing billions of invested capital shall be permitted to tell the Government of the United States that it cannot establish oil refineries for the benefit of all the people. And with the precedent of the Boulder Dam Bill before them, the Congressmen who might doubt the wisdom of the move would be hard-pressed to find an argument which could not be answered by that precedent. When the Congress of the United States commits itself to the proposition that in order to provide $10,000,000 of flood control the government may go into business to the extent of $125,000,000 to $200,000,000, the barriers are down. In no state in the Union would any business be safe from government competition, handled by federal bureaucrats and financed by the United States Treasury, because in every state the government is carrying on some function to which a huge business enterprise could be linked under the argument that the carrying on of the business was necessary in order to pay the expense of the government function.

I say, therefore, that if there was ever legislation proposed which challenged the rights of the states of the Union, we have such a proposal presented in this bill. It is not only the control of the federal government over the greatest river in the Southwest which is here proposed; it is an entering wedge for the removal from state control of large units in every great industry within our borders. This is no mere incident. The size of this proposal and the relation between the government-in-business feature and the legitimate government function is such that it must challenge the attention of every citizen who will for a moment give serious consideration to this aspect of it.

The right to tax and to regulate in the interests of our citizens those enterprises affected with a large public interest which are located within our borders is of the essence of state sovereignty. It is fundamental to the welfare of our citizens that the bodies which regulate their activities be located within the state's borders where complaints can be registered and heard without delay, where the conditions peculiar to the locality will be understood and where the regulating bodies are responsive to these conditions. Once the principle of control, ownership or regulation of local state industries by a federal bureaucracy is established by a measure such as the one under discussion, then we have saddled upon our people a new policy in government which will destroy the very foundation of the one we now enjoy. A new era in the struggle to maintain the sovereignty and rights of our states is apparently upon us, and, unless we are alert, organized minorities with their eyes upon the fat purse of Uncle Sam, and their ears deaf to warnings, will barter away our birthright.

The Proposed Legislation Is Unsound

This legislation is unsound in the legal justification for action by Congress and in the engineering and economic aspects.

The federal government has no right of authority over the Colorado River either as to the stream itself or the bed thereof, unless that authority can be found in the commerce clause of the United States Constitution. The federal government under the commerce clause has the right and power to make improvements upon a navigable river, and this authority can be exercised without regard to the consent of the states within the borders of which the river is located. The Colorado River is not now navigable in fact. In early pioneer days it was used for pioneer navigation. As has been pointed out by the government officials and engineers, this navigation has now been abandoned. Furthermore, there is no demand for its reinstatement. This legislation does not even purport to be for the purpose of improving navigation. On the contrary, the construction of the dam and the diversion of water as proposed in the bill would militate against navigation. The manifest and avowed purposes of the legislation are the development of power and the control of the river in the interests of irrigation and the prevention of floods. Assuming that an attempt were made to justify the erection of this dam and power plant under the commerce clause, it would be a clear case of an attempt on the part of Congress, under the pretext of executing one power, to accomplish an object not entrusted to the federal government. In the case of *McCulloch* vs. *Maryland*, 4 Wheat. 316, 423, it was pointed out by Justice Marshall that any such attempt would be held unconstitutional. He said in that connection:

> Should Congress, in the exercise of its power, adopt measures which are prohibited; or should Congress, under the pretext of executing its powers, pass laws for the accomplishments of objects not entrusted to the Government, it would become the painful duty of this tribunal, should a case requiring such a decision come before it, to say that such an act was not the law of the land.

The contention that Congress has the right to authorize this project on the theory that it has a duty to legislate for the reclamation of arid lands, or for the benefit of lands owned by the United States below the proposed structure, is not tenable. The Supreme Court has already definitely pronounced against any such authority. In the case of *Kansas* vs. *Colorado*, 206 U. S. 46, 51 L. Ed. 956, the Bureau of Reclamation made this contention, as stated by Justice Brewer in the following language:

> It rests its petition of intervention upon its alleged duty of legislating for the reclamation of arid lands; alleges that in or near the Arkansas River, as it runs through Kansas and Colorado, are large tracts of those lands; that the national government is itself the owner of many thousands of acres; that it has the right to make such legislative provision as, in its judgment, is needful for the reclamation of all these arid lands, and, for that purpose, to appropriate the accessible waters.

After pointing out that the Government of the United States was a government of enumerated powers, and that only the powers actually granted in the Constitution could be exercised by Congress, the contention so made was denied. There was also considered in that case another argument, which is sometimes made in behalf of this bill: that since there is no other adequate power to carry out this improvement that the United States should undertake it. In connection with that point the Supreme Court said:

> But, as our national territory has been enlarged, we have within our borders extensive tracts of arid lands which ought to be reclaimed, and it may well be that no power is adequate for their reclamation other than that of the national government. But, if no such power has been granted, none can be exercised.

And finally in that case the court said:

> But it is useless to pursue the inquiry further in this direction. It is enough for the purposes of this case that each state has full jurisdiction over the lands within its borders, including the beds of streams and other waters.

A long list of cases theretofore decided by the Supreme Court is cited in support of the last statement.

In the light of this and other decisions of the United States Supreme Court the only sound conclusion which can be reached is that there is no legal basis for the proposed action by Congress. If the states within whose borders this river flows do not consent to its control by Congress, and do not consent to the construction of this structure which would give that control, then Congress has no authority whatever to authorize the Secretary of the Interior, or any other agent of the federal government, to undertake its construction. If, therefore, Congress should pass this bill, it would be doing a futile thing, and would be merely contributing to delay in the development of the river which it purports to be undertaking.

The Company Point of View Regarding Boulder Dam

By C. Wellington Koiner
District Manager, Southern California Edison Company

THERE has been considerable discussion concerning the company point of view, that is, the attitude taken by the electric utility companies, particularly in Southern California, regarding the building of the Boulder Dam on the Colorado River.

The company point of view regarding the Colorado River development, or the building of the Boulder Dam, is briefly and tersely set forth in the following statement of Mr. John B. Miller, President of the Southern California Edison Company, in his financial statement of October 31, 1926, to the 105,000 stockholders of the company at that time. It sets forth the position of the company direct to its stockholders, and therefore cannot be construed as propaganda or intended for anything but the presentation of the facts of the company's position to the stockholders of the company, and therefore any amount of elaboration by additional words, or reference to the project could not set forth the point of view of the company more plainly, or directly, than that of Mr. Miller, whose statement is quoted herewith, verbatim.

Mr. Miller's Statement

"We would like to see it cease to be made a football to be kicked around in the working out of petty political plans. The political plans are too infinitesimally unimportant—the quality of the electric service too vital. Why jeopardize the one with the other?"

These words, from the *Wichita Democrat,* refer to a situation in Kansas, but they are equally significant when applied to the Colorado River.

The Boulder Dam proposal for the use of government funds has reached such a stage as to make it seem possible that Congress may make the necessary appropriation to put the program through, as no other program carries such a great weight of political support.

As far back as 1921 I said, "If it is possible for the Secretary of the Interior to secure from Congress an appropriation sufficient to erect a dam on the Colorado River, which will equate the stream, remove the menace from flood and establish the necessary water for irrigation, I believe it would greatly facilitate the whole development."

I reaffirm this statement. Whether the government proceeds under the Boulder plan, or under a better plan, I have always advocated that the power be made available, by a general co-operative plan, to all distributing agencies in the Southwest both corporate and municipal, in proportion to their present and prospective power demands.

However, the Swing-Johnson Bill in its present form includes the unnecessary feature of government financing and construction of powerhouses as well as a dam, thus injecting the government into the power business.

Neither the government nor its tenants would be subject to regulation by the Federal Power Commission. The Congress of the United States, in the year 1920, after more than ten years of deliberation, created this Commission and adopted a statute controlling the development of water power upon public lands. This was, in fact, a declaration by Congress of the national policy regarding development of water power in the country.

The principal objection to the pending bill has centered around this feature and it is believed, therefore, that the bill will be amended—as has been recommended by Secretary Herbert Hoover—to remove this objection. Such an amendment would not interfere with any of the benefits sought nor with the repayment of the cost of the dam to the government. The bill in its amended form would provide that the government construct the dam and that power development be made under the provisions of the national law and be subject to regulation by the Federal Power Commission. Any agency—municipal or corporate—desiring to develop power at the dam would have the opportunity to apply to the Federal Power Commission for a license so to do.

"Steam shovels and not politics will build Boulder Dam," says Mr. Hoover.

Federal Water Rights in the Colorado River

By Ottamar Hamele

Former Chief Counsel, United States Reclamation Service

It is a common saying of the arid West that no irrigator is so honest that he will not steal water in an emergency. Like most epigrams, this saying is not strictly true, but it emphasizes in a colorful way the high value placed upon that compound of hydrogen and oxygen, known to chemistry as H_2O, in the great desert regions of Uncle Sam's far-flung sunset domain. It also explains in a measure the many bitter quarrels, both between individuals and between sovereign states, carried on for years over claims to the use of the insufficient discharge of Western streams.

Notable among such conflicts between the states were the long fight by Kansas and Colorado relative to the waters of the Arkansas (*Kansas* v. *Colorado*, 206 U. S. 46), and the equally earnest contest between Wyoming and the Centennial State concerning the Laramie (*Wyoming* v. *Colorado*, 259 U. S. 419; 260 U. S. 1). Each of these battles was waged in the United States Supreme Court and was carried no further only for want of a higher appellate tribunal. In neither instance was either contender satisfied with the result.

By the Colorado River Compact, drafted in 1922 under the able guidance of Hon. Herbert Hoover, it was planned to eliminate some of the water controversy on the American Nile, through an agreement between seven states and the Federal Government, allocating rights to the use of the flow of that turbulent stream. However, after more than five years of heated discussion the proposed compact remains unratified.

The War of Western Water

This continuous War of Western Water is waged not only on the irrigation ditch, before the court, around the conference table, and through the channels of publicity, but also in the legislative hall. One of its major engagements is now being fought out in Congress over the proposal that the United States construct at Boulder Canyon on the Colorado, a great reservoir, for the fourfold purpose of controlling floods, irrigating lands, providing municipal water, and developing a huge block of electrical energy.

The enactment of the Swing-Johnson bill authorizing the building of the Boulder Canyon project probably would be followed by litigation. United States Senator Carl Hayden, speaking for the state of Arizona, has given notice that if the bill is passed Arizona will be compelled in self-defense to file a suit in the Supreme Court to restrain construction until the rights of that state in and to the Colorado River are determined. (*Congressional Digest*, February, 1927, p. 50.)

The silt-laden waters of this great stream are clearly not of the healing variety, and prospects for peace along its 1700 winding miles appear to be somewhat remote.

Any discussion of water rights on the Colorado River prepared for the consideration of the general reader, should be prefaced by a brief explanation of the doctrine of prior appropriation which obtains under local law in all of the seven States touched by the basin of that river. These seven states are Wyoming, Colorado, Utah, Nevada, New Mexico, Arizona and California.

The riparian water law of the humid East has been abrogated in each of these states, except California, where both riparian and appropriation rights are recognized. Under the doctrine of prior appropriation, he who first applies water to beneficial use either upon riparian or nonriparian land, acquires a vested property right to such use superior to the claims of all subsequent users. Such rights are recognized in the order of initiation until all of the water of the stream, if unnavigable, is utilized, and may be enforced without reference to State lines. (*Wyoming* v. *Colorado*, *supra*.)

THE POSITION OF THE FEDERAL GOVERNMENT

What may be called the official position of the Federal Government relative to the ownership of unappropriated water flowing in the unnavigable streams of the arid west, including the Colorado River, is stated on page 39 of the Annual Report of the Attorney General, dated December 7, 1914, as follows:

> The department takes the position that in the arid and semiarid regions, where the legality of diverting and appropriating water for beneficial uses on nonriparian lands is generally established, the original right of the Government to appropriate surplus water for its own uses, particularly for the reclamation of its enormous holdings of arid lands, has not been surrendered by any act of Congress or divested by the mere creation of states into which those regions have now become incorporated.

This claim of the United States was briefed and argued in the case of *Wyoming* v. *Colorado*, *supra*, first by Solicitor General John W. Davis, and later by Solicitor General James M. Beck, but the point was not passed upon in that case.

With unimportant exceptions, the territory lying in the Colorado River basin was acquired by the United States from Mexico under the treaty of Guadalupe Hidalgo of February 2, 1848, 9 Stat. 928. By that convention the United States became the exclusive and absolute owner, both as a sovereign and as a proprietor, of all of said watershed, the right as a proprietor being subject only to vested individual rights and such Indian rights as might be recognized. This ownership necessarily included both the land and the water.

Article IV, Section 3, of the Constitution provides that—

> The Congress shall have power to dispose of and make all needful rules and regulations respecting the territory or other property belonging to the United States.

This power to dispose of the public domain is defined by the Supreme Court in *Gibson* v. *Choteau*, 13 Wall. 92, 99, as follows:

> With respect to the public domain, the Constitution vests in Congress the power of disposition and of making all needful rules and regulations. That power is subject to no limitations. Congress has the absolute right to prescribe the times, the conditions and the mode of transferring this property or any part of it and to designate the persons to whom the transfer shall be made. No state legislation can interfere with this right or embarrass its exercise.

The public waters were a part of the public domain, were property of the United States within the meaning of the Constitution, and could be disposed of apart from the land. There are many decisions to that effect.

In *Cruse* v. *McCauley*, 96 Fed. 369, 373, the court states that—

> As the United States owns the waters which are incidental to its lands, it can dispose of them separate from its lands if it chooses.

The Supreme Court of Oregon, in *Hough* v. *Porter*, 51 Ore. 318, says:

> The water flowing over the public domain is a part thereof, and the general government may grant or otherwise dispose of its riparian interests separate from the rest of the estate.

The following language is used in *Howell* v. *Johnson*, 89 Fed. 556, 558:

> Being the owner of these lands it (the United States) has the power to sell or dispose of any interests therein, or any part thereof. The water in an innavigable stream flowing over the public domain is a part thereof, and the National Government can sell or grant the same, or the use thereof, separate from the rest of the estate under such conditions as may seem to it proper.

It thus appears that the United States at one time had an ownership in the public waters of the Colorado River Basin, and that these waters were susceptible of disposition independently of the land in the same area. The question then arises: Has the Government transferred its rights in these waters?

THE GRANT OF FEDERAL WATERS

A search of the Acts of Congress will disclose but a single grant, which is contained in the Act of July 26, 1866, 14 Stat. 251, as supplemented by the Act of July 9, 1870, 16 Stat. 217. This grant was carried into the Revised Statutes as Sections 2339 and 2340, and later into Title 43, Section 661, of the United States Code, reading as follows:

> Section 661. *Appropriation of waters on public lands; right of way for canals and ditches.*—Whenever, by priority of possession, rights to the use of water for mining, agriculture, manufacturing, or other purposes, have vested and accrued, and the same are recognized and acknowledged by the local customs, laws, and the decisions of courts, the possessors and owners of such vested rights shall be maintained and protected in the same; and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed; but whenever any person, in the construction of any ditch or canal, injures or damages the possession of any settler on the public domain, the party committing such injury or damage shall be liable to the party injured for such injury or damage.
>
> All patents granted, or preemption or homesteads allowed, shall be subject to any vested and accrued water rights, or rights to ditches and reservoirs used in connection with such water rights, as may have been acquired under or recognized by this section. (R. S. Sections 2339, 2340.)

This grant was made primarily for the purpose of protecting the investments made by early settlers in California, who, without authority, had appropriated and used land and water belonging to the United States, under local customs, laws, rules, and regulations. It has been held to be prospective in operation. (*Union M. & M. Co.* v. *Ferris*, 2 Sawy. 176, 24 Fed. Cas. No. 14,371.) The effect of this legislation clearly is that of a direct grant by the United States to the user of water where the latter is complying with the local laws, customs and statutes of the state within which the claim is made. The grant is limited to users of water; it does not run to a State or any other political body.

This grant has been somewhat amplified in the public land laws relating to the acquisition of water rights by individual appropriators, notably in the Desert Land Act of March 3, 1877, 19 Stat. 377, and in the National

Irrigation Act of June 17, 1902, 32 Stat. 388. But again, all of this legislation relates alone to rights acquired by the application of water to beneficial use. There has been no blanket transfer out of the Federal Government.

THE DESERT LAND ACT

It has been argued that the Desert Land Act, just referred to, made a "dedication" of Federal water to the states. The pertinent provision reads as follows:

> That the right to the use of water by the person so conducting the same, on or to any tract of desert land of six hundred and forty acres shall depend upon bona fide prior appropriation; and such right shall not exceed the amount of water actually appropriated and necessarily used for the purpose of irrigation and reclamation; and all surplus water over and above such actual appropriation and use, together with the water of all lakes, rivers, and other sources of water supply upon the public lands and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes subject to existing rights.

A brief examination of the quoted provision will show that it contains no grant to the states. They are not mentioned as would be the case if they were grantees. The act deals with individual appropriators as did the acts of 1866 and 1870. Congress lays down certain requirements of a water right, and speaks as would an owner regulating his own property.

A general transfer of Government property cannot be implied. A statute cannot be construed to affect any right of the United States in the absence of express language so providing. (*U. S.* v. *Oregon Co.*, 186 Fed. 861, 893; *Oregon R. R.* v. *Oregon Ry.*, 130 U. S. 1, 26; *Coosan* v *State*, 144 U. S. 550.)

Also, it has been urged that Federal grants of land have included a transfer of Federal water. The answer to this claim is that under the law of prior appropriation a grant of land from the Federal Government does not carry riparian rights. (*Coffin* v. *Left Hand Ditch Co.*, 6 Colo. 443; *Clark* v. *Ashley*, 34 Colo. 285.)

Again, it is argued that the admission of a state into the Union, under a constitution declaring water to be the property of the public subject to appropriation through state laws, constitutes a grant to the state of Federal water.

As has been shown, Congress alone has the power to dispose of public land and water, and a state constitution, even when supervised and ratified by Congress, is not an act of Congress. (*Coyle* v. *Smith*, 221 U. S. 559, 568; *Ex parte Webb*, 225 U. S. 663, 690.)

The Federal Constitution is a grant of powers, but state constitutions are limitations on power, not grants. The Supreme Court of Colorado, in *Packer* v. *People*, 8 Colo. 364, quotes with approval from Cooley on *Constitutional Limitations*, as to the nature of a state constitution, as follows:

> It is not the beginning of a community nor the origin of private rights. It is not the fountain of law nor the incipient state of Government. . . . It grants no rights to the people; but it is the creature of their power, the instrument of their convenience.

THE NATIONAL IRRIGATION ACT

It is further contended that Section 8 of the National Irrigation Act is a surrender of Federal water rights to the states. This section reads as follows:

> That nothing in this act shall be construed as affecting or intended to affect or to affect or to in any way interfere with the laws of any state or territory relating to the control, appropriation, use, or distribution of water used in irrigation, or

> any vested right acquired thereunder, and the Secretary of the Interior, in carrying out the provisions of this act, shall proceed in conformity with such laws, and nothing herein shall in any way affect any right of any state or of the Federal Government or of any landowner, appropriator, or user of water in, to, or from any interstate stream or the waters thereof: *Provided*, That the right to the use of water acquired under the provisions of this act shall be appurtenant to the land irrigated, and beneficial use shall be the basis, the measure, and the limit of the right.

The first clause of the quoted section is merely a restatement of the general policy of the Government as it appears in the acts of 1866 and 1870.

The second clause, to the effect that the Secretary of the Interior in carrying out the National Irrigation Act, is to proceed in conformity with state laws, is the usual Federal "conformity" provision, such as is found in the statutes concerning condemnation—a conformity with the laws of the state in so far as those laws do not interfere with the rights of the United States. It is significant that there is no provision in the National Irrigation Act requiring the Government to "appropriate" any water. The Secretary of the Interior is authorized by Sections 4 and 5 to sell the Government's water and by Section 7 to buy or condemn water rights, but nowhere in the act is it suggested that it is necessary for the United States to make an "appropriation."

The quoted section also provides that "nothing herein (in Section 8) shall in any way affect any right . . . of the Federal Government . . . in, to, or from any interstate stream or the waters thereof." The Colorado River is an interstate stream and therefore no right of the Federal Government therein held at the time of the passage of the National Irrigation Act in 1902 was affected by the section quoted.

This section further requires that the water rights acquired by individuals thereunder shall be appurtenant to the lands irrigated. This is a declaration of Government ownership and control of its waters, as this provision is contrary to the water law of several Western states, providing that water rights are not appurtenant to the land irrigated.

The point under consideration is admirably summed up by Mr. Kinney, one of the leading authorities on Western water law, as follows:

> Our conclusions upon this subject are, that the United States, as the original owner of all of the land on the public domain, was also the owner of all the waters of the natural streams and other bodies flowing thereon. By various Acts of Congress the United States has disposed of some of these waters under the Arid Region Doctrine of appropriation; and that the United States is still the owner of these waters, which have not been disposed of, regardless of the action of the state or territory wherein they are located. The right to the use of other of its waters has also vested in the individuals who have from time to time acquired tracts of lands from the Government bordering upon the streams, as a riparian right, in those states where those rights are permitted. It was left to the various states, as a matter of sovereignty or jurisdiction to prescribe how the title to the use of the waters might be acquired by individuals, in accordance with its local customs, laws, and decisions of the courts. When the local customs, laws, and decisions of the courts had been fully complied with by an individual seeking to acquire a water right the title to the same vested in the individual direct from the United States, and not from any state. 2 Kinney, Irrigation. (2d. ed.) Sec. 640.

From the foregoing it seems quite clear that the United States is still the owner of the unappropriated waters of the Colorado River, and may utilize them for public purposes without the consent or approval of any of the seven states touched by the watershed of that stream.

SPECIAL AUTHORITY FOR CONSTRUCTION OF BOULDER DAM

As to the proposed Boulder Canyon development, there is a special reason why the state of Arizona, which is one of the principal objectors thereto, is not in a legal position to interfere with the same. That state entered the Union under an enabling act which expressly retained in the Federal Government the right to carry on operations of this character. The pertinent provisions of the law (Act of June 20, 1910, 36 Stat. 557, 570, 574, 575) are as follows:

> That there be and are reserved to the United States, with full acquiescence of the state (Arizona) all rights and powers for the carrying out of the provisions by the United States of the act of Congress entitled "An Act appropriating the receipts from the sale and disposal of public lands in certain states and territories to the construction of irrigation works for the reclamation of arid lands," approved June seventeenth, nineteen hundred and two, and acts amendatory thereof or supplementary thereto, to the same extent as if said State had remained a Territory.
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> . . . no lands (in Arizona) which are or shall be susceptible of irrigation under any projects now or hereafter completed or adopted by the United States under legislation for the reclamation of lands, or under any other project for the reclamation of lands, shall be sold at less than twenty-five dollars per acre: *Provided*, That said state, at the request of the Secretary of the Interior, shall from time to time relinquish such of its lands to the United States as at any time are needed for irrigation works in connection with any such Government project; and other lands in lieu thereof are hereby granted to said state, to be selected from lands of the character named and in the manner prescribed in section eleven of this act.
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> . . . . .
>
> There is hereby reserved to the United States and exempted from the operation of any and all grants made or confirmed by this act to said proposed state all land actually or prospectively valuable for the development of water powers or power for hydroelectric use or transmission and which shall be ascertained and designated by the Secretary of the Interior within five years after the proclamation of the President declaring the admission of the state; and no lands so reserved and excepted shall be subject to any disposition whatsoever by said state, and any conveyance or transfer of such land by said state or any officer thereof shall be absolutely null and void within the period above named; and in lieu of the land so reserved to the United States and excepted from the operation of any of said grants there be, and is hereby, granted to the proposed state an equal quantity of land to be selected from land of the character named and in the manner prescribed in section eleven of this act.

Attention is particularly directed to that clause which reserves to the United States all rights and powers for carrying out the provisions of the National Irrigation Act of June 17, 1902, under which the Boulder Canyon dam would be constructed, "to the same extent as if said state had remained a territory." Before statehood Congress has plenary power over a territory unlimited even by the restrictions of the Constitution. The right of Congress to reserve Federal waters cannot be denied. (*Winters* v. *United States*, 207 U. S. 564.) Congress may even annul an act of a territorial legislature or legislate direct for the local government. (*Brunswick First National Bank* v. *Yankton Co.*, 101 U. S. 129; *Baca* v. *Perez*, 8 N. M. 187, 42 Pac. 162.) Were Arizona still a territory no one would question the right of the United States to deal with the public land and water therein as Congress might direct. It seems to follow that because of the reservations in the enabling act no one can successfully question it now. And it should be added that an Arizona appropriation of water, good in that state, is also good throughout the entire stream system. (*Wyoming* v. *Colorado*, *supra*.)

A full recognition of the rights of the Federal Government to the unappropriated water of the Colorado River, would lead to most admirable results. Because of the interstate character of this stream, a general control outside of the seven interested states is peculiarly desirable. The United States has no interest adverse to any state, and should be able to do justice to all. Through such a control, much long, expensive and unsatisfactory litigation, such as that involved in the eleven-year quarrrel between Wyoming and Colorado, heretofore referred to, could be avoided. Questions as to conflicting rights could be quickly and finally settled, with a view to protecting all interests of the basin, rather than those of a single state.

It is indeed to be regretted that a wise and understanding statesmanship did not definitely settle this question as to each state by clear, explicit provisions in an enabling act. That was done fairly well as to public land; it should have been done as to public water. Then a truly constructive result would have been achieved and the casualties in the War of Western Water would have been materially reduced.

The Boulder Canyon Project

By Hon. Hiram W. Johnson

United States Senator, California

THE Boulder Canyon project, now before the Congress of the United States in the Swing-Johnson bill, is without a doubt the greatest constructive project pending before Congress at this time, and indeed, the greatest constructive project of our generation. There is nothing comparable to it within our memories, save the construction of the Panama Canal. It is a project of national importance, not only because of its importance for the control of floods, the reclamation of land, the conserving of water for domestic use, but also because the great private power interests have elected to make this bill the focal point in the struggle to retain in private monopoly the development of power. Here will be developed electric energy in the amount of 550,000 firm horse power which the bill provides shall be available for all the people. But the gigantic power combine is determined that this power shall be for their monopoly alone and this is the real issue upon which the opposition to the Swing-Johnson bill is based.

The Swing-Johnson bill for the development of the Colorado River is the result of years of labor and research on the part of the best engineering minds of the country to produce a workable plan, just and fair to all interests and sections. It provides, first, flood control and river regulation; secondly, reclamation of a million or more acres now waste; thirdly, domestic water for the coastal cities of the southwest; fourthly, an all-American canal to the Imperial Valley upon American soil, solving the present intolerable international situation; and lastly, as a by-product of the plan, the generation of power, which will enable the project to pay for itself.

THE SWING-JOHNSON BILL

The Swing-Johnson bill provides for the building of a dam at Boulder or Black Canyon on the boundary of Arizona and Nevada. It proposes at that point to erect a dam 550 feet in height—the highest dam that now exists in the world—in order to store there by virtue of that dam 26,000,000 acre feet of water, creating a lake that will extend back almost one hundred miles from the dam, thus regulating the flow of the river, thus controlling its floods, and making the Colorado River, the third largest in the United States, a servant to mankind and a servant to the territory through which it flows.

The estimated cost of the project, as given by the Secretary of the Interior in his report of January 12, 1926, recommending the authorization of this project, is $104,000,000. This estimate is not mere guesswork but the result of long and painstaking studies by the Interior Department, and consultation with some of the leading engineers of the nation in addition to those of the Reclamation Service. The figures compiled have in turn been carefully checked and rechecked by the engineers and experts of the Imperial Irrigation District and others interested in the project. The same engineers have also estimated that sale of power and the returns from water storage will return a gross annual revenue of $12,-

300,000, or a net annual surplus of $6,100,000, or sufficient to repay the entire cost of the project with interest in twenty-five years.

The Swing-Johnson bill provides that no work shall be begun on the project nor any action be taken in regard to any water rights until the states interested, or at least six of them, have approved the Colorado River compact. The states having an interest in the Colorado River development are Wyoming, Colorado, Utah, and New Mexico, the so-called Upper Basin States, and Arizona, Nevada and California, the Lower Basin States.

The Colorado River compact is a compact for the settlement of water rights on the Colorado River by inter-state agreement and was signed by representatives of the seven states on November 24, 1922. All of the states except Arizona ratified the compact at that time. Later, in 1925, a six-state ratification of the compact was suggested, and this was approved by the four Upper Basin States and Nevada. California approved the compact under the six state plan with her approval to become effective when legislation was enacted which would provide for a high storage dam at Boulder Canyon. Such storage would conserve and make available for use in the states below the vast quantities of flood waters which now waste to the sea. Without this protection California felt that her rights to the water required for her needs would not be safeguarded. Although the Swing-Johnson bill safeguards in every way the rights of the Upper Basin States to their share of the water, Utah during the last session of Congress withdrew her ratification of the compact. Arizona has consistently refused to ratify any compact, basing her refusal on various pretexts; but the most evident reason is the desire of the state of Arizona to secure a revenue from any development of the Colorado River, either in the form of taxation of the works or a royalty on any power generated. There is no quarrel with Arizona on the part of California in regard to the division of the water and many conferences between the commissioners of the two states have indicated that California is willing to go more than half way in giving Arizona a large share of the water of the river. During the last fall conferences of representatives of all of the states were held at Denver in an endeavor to reach an agreement for the distribution of water and power which would be agreeable to all states interested in the Colorado River development. No definite agreement was reached and the conference only served to make it more evident that this project is bigger than an inter-state project. It is a national project in which the Federal Government has a deep interest and it must be constructed and its product of water and power distributed under federal supervision. The Denver conferences have only emphasized this fact. This in brief is the Boulder Dam project and what the Swing-Johnson bill proposes to do in making it a reality.

THE SERVICE OF BOULDER DAM

The problem of flood control and river regulation is a pressing one and one whose early solution is necessary if the fertile valleys of the Imperial and Yuma are to be preserved. The Imperial Valley lies in the southeasterly portion of California. On the south it is bounded by the Mexican line. Its easterly edge is about forty miles west of the Colorado River. Centuries ago the Imperial Valley was the northerly end of the Gulf of California. The tremendous quantities of silt carried by the river gradually built a huge delta or dam across the gulf completely cutting off the northern end. Evaporation gradually dried up this section and left, lying in the form of a huge bowl, what is now the Imperial Valley. Around the rim of this bowl from 100 to 350 feet above the cultivated and settled areas runs the Colorado River. The river is building up its channel higher and higher through the deposit of more than 100,000 acre feet of silt carried down by its sediment loaded waters annually. This means that levees must be raised higher and higher with greater costs and with increasing danger of failure. A break will mean the loss of all that has been built up in thirty years by the men and women who have reclaimed this region from the desert. Experts are agreed that, unless the floods are controlled and the silt eliminated, it is only a matter of a few years until levees will no longer hold the Colorado in its present channel; when the inevitable break will come and the waters turned into the Imperial Valley. Since the Valley has no outlet this means permanent inundation and destruction for all time of the millions of dollars in property as well as probable loss of human life. The Boulder Dam will forever end the flood menace of the lower river. The huge reservoir will catch and hold the flood waters until they can be released gradually at a rate the river channel can accommodate with safety. Silt now deposited in the lower reaches of the river, aggravating and to a large extent causing the flood danger, will be intercepted and held at the reservoir.

With the danger of flood removed and a regulated flow of the stream assured, but one more thing would be needed to assure the Imperial Valley of an adequate supply of irrigation water and continued development. That need is the all-American canal, provided by the Swing-Johnson bill. The present main canal which supplies the irrigation and domestic water for the Imperial Valley runs for sixty miles through Mexican territory. This canal is under the control of a Mexican corporation, subsidiary to the Imperial District, and subject to a contract with the Mexican government that gives to the landowners on the Mexican side of the boundary, one-half of the water flowing in the canal. As irrigation uses have increased in Mexico the water available for irrigation in the Valley during the period of the low flow of the river has grown less and less, as the Valley gets what water is left after the Mexican users have supplied their needs.

The building of the all-American canal as provided by the Swing-Johnson bill will put an end to the intolerable situation which now exists with the Imperial Valley water supply under Mexican control. The seriousness of the situation may be realized by the fact that, if the supply of water delivered by this canal were interfered with for only a period of a few days, Imperial Valley would not only be faced with financial ruin from the destruction of all crops but the people themselves would have to move from the Valley as no other source of water is available even for drinking purposes. If there were any difficulty with Mexico, the Mexicans could take possession of the present canal which is the jugular vein of the Imperial Valley. With one stick of dynamite one hundred million dollars worth of property and the homes of happiness of sixty thousand or more people could be destroyed.

Another important feature of the all-American canal is that it will assure the landowners of the Imperial Valley an abundant water supply at all times which will enable them to develop their land to the fullest advantage. This they cannot do at present because of the first call on the water by the owners of lands in Mexico. This land owned by American capitalists is being cultivated with Oriental and other foreign labor in direct competition with the citizens of the United States on United States territory. These owners of Mexican land claim the right to receive water through the Imperial canal sufficient to irrigate an acreage in Mexico equal to that irrigated through that canal in the United States. The unregulated flow of the Colorado River will supply water for only about 600,000 acres, and there are now under cultivation 400,000 acres in the United States and 200,000 acres in Mexico. Hence, for every additional acre that is hereafter placed under cultivation in Mexico, an acre of land now under cultivation in the United States must return to the desert. With the Mexican acreage under cultivation showing a yearly increase, it can easily be seen that the situation is becoming more intolerable all the time.

Some objection has been voiced to this development that it will bring more land under cultivation in competition with lands now being cultivated in other parts of the nation, especially with the cotton growers of the South. The competition in cotton growing comes almost entirely from the Mexican side of the border. Long since the Imperial Valley farmers found they could secure much greater returns from diversified vegetable and fruit crops than from cotton, but on the Mexican side, with cheap labor, cotton is the crop on about ninety per cent of the land under cultivation. Continuance of the present condition, or the building of a purely storage dam without the all-American canal, will mean that the Mexican landowners will be among the greatest beneficiaries from the use of the waters of the Colorado and they will steadily increase their acreage in competition with staple American products such as cotton.

The all-American canal will be at sufficient elevation to carry water to additional land, mostly public, lying along the rim of the Imperial Valley and in the Coachella Valley. The Imperial Valley might well be called "America's hothouse," and from it are supplied to the nation at off season vegetables and small fruits of all kinds, none of which come in direct competition with any other community. Dates and other tropical fruits not grown elsewhere in the United States are also products of this rich section. For this reason any new land brought under cultivation by the all-American canal or by the development of the Colorado River will produce these same crops and add nothing to the farm problems of the nation.

The Swing-Johnson bill provides that all lands practicable of irrigation and reclamation by the irrigation works authorized shall be withdrawn from entry, and when the works are sufficiently constructed to permit the delivery of water the same shall be open to entry in tracts not exceeding 160 acres, with preferential right to persons who have served in the United States Army, Navy or Marine Corps. There are 166,900 acres known to be irrigable from the all-American canal which will be subject to such entry. In addition there will be considerable land in Arizona which will benefit by the increased water supply.

The construction of the high dam at Boulder Canyon will, incidentally, enable the cities of southern California, now threatened with a water shortage due to rapidly increasing population, to secure additional water supply for the domestic use of their inhabitants. The present sources of supply have been exhausted and the Colorado River is the only available source for the present population of the southern California coastal belt of approximately two million. About 1500 second feet of water will be required to supply this need. The cities interested, headed by Los Angeles, have taken steps to form a metropolitan water district to handle the building of an acqueduct two hundred and sixty miles long from the Colorado River and to provide for the distribution of the water. They are prepared to spend $150,000,000 for this purpose and have already spent a considerable amount in preliminary work. The large storage proposed at Boulder Dam will impound the flood waters that now go to waste and provide an excess over irrigation needs sufficient to supply these requirements for domestic use. The storage of this water and its delivery to the cities will provide a revenue to the government from the project. The fact that it will be necessary to pump the water over a mountain range to southern California will also provide a market for much of the power generated at the dam.

OPPOSITION OF THE POWER MONOPOLY

We have here then the purposes to which the Swing-Johnson bill is dedicated and what will be accomplished by the completion of the Boulder Dam project—flood control and river regulation, reclamation of lands and the emancipation of American land from Mexican control by the building of the all-American canal, and providing domestic water for the cities of southern California. Surely there is nothing in this beneficial program to arouse the nation-wide opposition to the Boulder Dam project that is now making its appearance at every convention of a national character. But the Swing-Johnson bill, at the behest of the Secretary of the Interior, provides that the Secretary of the Interior be authorized in his discretion to construct power plants as part of the project and to sell power wholesale at the switchboard to municipal corporations, political subdivisions and private corporations. Or he may lease the water at the dam to various applicants for the generation of power. This is for the protection of the government in the financing of the dam; a guarantee that the government will be repaid for its cost.

For years the private power companies have had visions of the potential value of the Colorado River as a source of electric energy. They also saw the cities of the California southern coastal belt increasing in population and in industries, with ever increasing demand for power, and their plans for the future included an absolute monopoly of the power resources of the Colorado River. Then came the Boulder Dam project with its provision that the people themselves as represented by their municipalities or their irrigation districts would have the right to buy power direct from the switchboard at the dam or to build generating plants of their own using the stored water.

The rights of the people to secure the fruits of this great national resource did not enter into the plans of the power combine and there has now been mobilized to prevent it one of the most powerful lobbies that has ever been assembled at Washington. Over the nation is being spread a mighty flood of misleading and false propaganda against the Boulder Dam project. Every source of propaganda that is conceivable today is in operation against this monumental work. Every single kind of publication that can be utilized against the building of this dam is now utilized in every part of the United States. Under the name of the

Joint Committee of the National Utility Association of 420 Lexington Avenue, New York, representing, as one of its officials boasted during last session of Congress "an investment of $7,000,000,000 which does not propose to permit the Government to enter the power business at Boulder Dam," the power combine is making its battle against this project.

THE ACTUAL PROVISIONS AS TO POWER

What are the facts about the power provision of this bill? The facts are all in the record of the hearings before the committees of Congress. When the bill was before the committee on Irrigation and Reclamation in the Senate, as was usual, it was transmitted to the Secretary of the Interior, under whose jurisdiction it comes, for his comment, his amendments and his approval or disapproval. When the bill was thus submitted to the National Administration, it contained no provision for the construction, either optional or otherwise, by the Government, of a plant for generating electricity. On the 10th day of January, 1926, the Secretary of the Interior reported upon the bill to the Senate Committee and in this report the Secretary expressed opposition to the allotting of power privileges, as proposed in the Senate bill, and advocated the building of a unified power plant by the Federal Government as more efficient and cheaper resulting in the elimination of controversies between applicants and long delays in their adjustment. In detail he gave his views as follows:

> The building of a unified power plant by the Federal government in the place of allocating power privileges, as proposed in the bill, is regarded as more efficient and cheaper. It will obviate controversies between applicants and long delays in their adjustment. In the end, I believe, results will be superior to those under an allocation of privileges. The area for the location of separate power sites is restricted. Allotments would not be equal in value. Some allottees would therefore have an advantage over others. It would result in the creation of operation and administration controversies to be avoided and which a unified development would avert.

Thereafter, in accordance with the direction of the Secretary of the Interior, representing the administration, the bill was amended so that a permission was given to the United States government hereafter, if it saw fit, to construct a generating plant at the dam. This provision was an option, a permission, a mere right if in the discretion of the Secretary it might seem wise thereafter to construct a generating plant. With this amendment the bill received the hearty approval of the Secretary of the Interior and the Secretary of Commerce and the endorsement of the President of the United States. The Secretary was entirely right in his views and none can question either the wisdom or necessity for the particular provision.

It prevents the monopolization of the power resources of the Colorado River. Such monopolization by any private agency would dominate the industrial and political life of the Southwest. With the government in control of the development, and the power made available allocated to various agencies, the danger of monopolization of the power of the Colorado River is forever effectively removed.

Out of the insertion of this provision in the bill at the request of the Secretary of the Interior for the full protection of the government in the financing of the project and that all who might benefit from the generation of power might have equal rights, has come the terrific opposition now directed against the Swing-Johnson bill; the marshall-ing of billions and the calling to arms of every adherent of industrial monopoly and corporate control of utilities.

THE MENACE OF THE POWER LOBBY

The United States Government must have neither option hereafter nor permission to exercise a discretion in the greatest undertaking since the Panama Canal. The power trust says so and in advance vetoes legislation. It challenges not only independence of congressmen and senators but challenges the very government itself. It not only puts its profits above a people's welfare but says a people's government must do likewise.

They cry that the "government is going into business," that it is competing with private ownership and investments on an unfair basis.

This is not really an issue of government ownership at all. It involves no transmission of power by the government, leasing only either of power at the switchboard or water for the purpose, as the Secretary of the Interior in the exercise of a wise discretion may decide. The power companies are unwilling to trust the Secretary of the Interior and the present administration and demand that no discretion shall be given them. They frankly say they fear the establishment of a precedent and that in relation to the last great natural resource of the nation, they will take no chances on its preservation for the people, but that it must be administered primarily for the hydroelectric power companies.

To accomplish their purpose they have gathered at Washington, representing the public utility organizations of the nation, this great lobby. They have the active aid of men like Samuel Insull, who controls the power utilities of the Middle West and who is charged with having gone so far as to purchase a United States senatorship on behalf of his monopoly. To all the stockholders of his companies has been sent a notice warning them of the dangers of the Boulder Dam project.

The situation is really the age-old struggle of those who hold that what God gives belongs to the people and those who hold that it belongs to the few. The issue has been made, and it must be met at this session of Congress by every self-respecting legislator, and by every man who believes that the government, dealing with its own, is superior to any private interest.

Muscle Shoals, Nitrogen and Farm Fertilizers

By R. O. E. Davis

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ONLY about twenty-five years ago, a warning was issued by Sir William Crookes that the world's supply of available nitrogen was running short and a method of fixing the uncombined nitrogen of the air should be devised if the world was not to suffer in its food supply. From that time much progress has been made until today serious consideration is being given as to the best methods of utilizing the nitrogen that is or may be made available. The use as fertilizer is believed to be the field for the largest consumption of nitrogen. No longer is there any doubt as to the possibility of fixing nitrogen; the problems now are connected largely with commercial development and with the utilization of the fixed nitrogen products, even though great improvements may be made in nitrogen fixation processes. In discussing the subject indicated by the title, it is therefore necessary to trace somewhat the development of the methods of fixing nitrogen and outline to some extent the changes that have come about since the question of Muscle Shoals was first presented and also the tendencies of the nitrogen fixation industry.

NITROGEN IN NATURE

Nitrogen occurs in nature in largest amount as uncombined gas in the atmosphere, of which it constitutes about four-fifths by volume. It is also a constituent of mineral deposits, the principal one of which is the Chilean nitrate beds; it occurs in coal, in animal and vegetable residues and in the living tissues. It is indispensible to animal and vegetable life, just as essential as carbon, hydrogen or oxygen. And yet neither animals nor plants can utilize directly the nitrogen of the atmosphere. There is a natural cycle which roughly may be indicated as free nitrogen entering into combination through the agency of bacteria or under the influence of electric discharges, these combinations entering the plant and being transferred from plant to animal and finally through bacterial agencies returning again to free nitrogen, or remaining in the soil in accumulations under certain conditions.

An element so essential in life processes, when applied in assimiliable and suitable form to the soil results in greatly stimulating plant growth and thus becomes important as a fertilizer. An interesting estimate or what may be more accurately called a speculation, has been made concerning the annual losses of nitrogen by Dr. J. G. Lipman of the New Jersey Experiment Station. This loss of nitrogen from all land under cultivation in the United States is stated as between 3,000,000 and 4,000,000 tons, after due account is taken of the amount returned to the soil by manures, by leguminous crops, by atmospheric precipitation as rain or snow, and by the application of commercial fertilizers. This amount of nitrogen is equivalent to 15 to 20 million tons of ammonium sulphate or of nearly 200 million tons of ordinary mixed fertilizer. Part of this loss would occur under natural conditions, but part of it is brought about through cultivation with resulting increase in leaching and more rapid oxidation of soil organic material. These losses may be decreased by the conservation of natural sources, or the employment of certain crops or rotations to increase the natural supply. The employment of better means of preventing soil erosion or leaching will add materially to the nitrogen conserved. The better use of green manures, and plant residues, the better conservation of animal manures, and the maintenance of soils in a condition suitable for the growth of nitrogen-fixing organisms will all contribute toward increasing the supply of nitrogen available. After all these resources have been utilized to the fullest extent, however, there will still remain a deficit of available nitrogen which must be met at some future time. There is no source capable of meeting the ultimate demand except the atmosphere. With most of the better agricultural lands already under cultivation, the world must in the future look to increased production to feed the increasing population of the world. There are many factors involved in bringing about increased production, but not the least of these is the application of commercial fertilizers.

There will probably be immediate objection to increasing the production of farm products, but this objection holds only at present as to total production. Increasing the yields per acre and making the labor more efficient is not objectionable, for it means cheaper production costs, and the release of labor for other useful work. And this is just what can be accomplished with the application of fertilizers. In general the farmer may raise with less labor and on less land the same amount of crop with the application of fertilizers that he does with more labor and on more land without fertilizer; and the cost of the fertilizer does not by any means equal the increased value of his crop. There are exceptions to this, but as a general rule, the use of fertilizers on soils of humid regions is profitable.

SOURCE OF NITROGENOUS MATERIALS

It has just been stated that the only source of nitrogen capable of meeting the ultimate demand for agricultural purposes is the atmosphere, but in order to understand the situation we should give some attention to the other sources of nitrogen. The first and most important supply of nitrogen has been sodium nitrate derived almost exclusively from the Chilean deposits. This supply is already beginning to feel very keenly the competition of the fixed nitrogen from the air. While undoubtedly it will continue for a long time to be an important material, the decreasing production and use of Chilean nitrate has already begun.

The second source of importance is ammonium sulphate derived as a by-product from coke ovens and gas plants. With our present methods of manufacture of pig iron, it is most likely that the production of this material will not decrease. That there may not be the great increase anticipated in some quarters by the increasing demand for coke for domestic purposes is possible, but the commercial development of methods of producing liquid fuel from coal may ultimately increase the supply of ammonium sulphate. This industry can hardly be said to be in its infancy yet, but its development may so influence the fuel industry and incidentally the ammonium sulphate supply that its effects cannot be foretold at present.

In addition to these two larger sources of nitrogen, there are many smaller ones, mostly of organic materials, such as cottonseed meal, slaughterhouse tankage and waste products such as dried blood, fish scrap, garbage tankage and other minor materials. Much of these materials has been and is being lost to fertilizers and is going into feed stuffs because of their higher value in this field.

ATMOSPHERIC NITROGEN FIXATION PROCESSES

A survey of existing sources of materials aside from nitrogen fixation processes shows that the prospects of enormously increasing production is not likely and for the future the increased demand must be met from the atmospheric nitrogen. This has been recognized for nearly thirty years and investigations on methods of nitrogen fixation have been stimulated to meet the demand. The World War, however, furnished the greatest impetus to the development of the fixation industry.

The three types of processes that have attracted most attention in the development of the nitrogen fixation industry are known as the arc, cyanamide, and direct synthetic-ammonia processes. The first of these is based on the most obvious method of fixing nitrogen, that is bringing about the combination of the nitrogen and the oxygen of the air and absorbing the nitrogen oxides produced in water to form nitric acid. This combination is effected by the passage of an electric arc through the air. The energy consumed per unit of nitrogen fixed is very high and so the process is applicable only where power is very cheap. The second or cyanamide method, which employs coal, coke, limestone and nitrogen from the air to produce a solid substance carrying about 22 per cent nitrogen, also requires much power, but only about one-fourth the amount per unit of nitrogen of that required for the arc process. It is sufficiently high, however, to demand comparatively cheap power for the successful operation of the process. The third or direct synthesis method, in which hydrogen and nitrogen combine under the influence of a catalyst to form ammonia, requires about one-fourth the power of the cyanamide process, and here a condition is reached where power is not so important a consideration in the process.

THE NITROGEN SITUATION AT THE BEGINNING OF THE WORLD WAR

The situation at the beginning of the World War was such that, while the world was familiar with the arc and the cyanamide processes for fixing nitrogen, Germany alone had developed the direct synthetic method on a commercial scale. The United States just before its entrance into the war realized that there should be some additional supplies of fixed nitrogen within the country. The demand for increased supplies was partially met by the increase in by-product ammonium sulphate from coke ovens. Even this was not sufficient, and in the National Defense Act of June 3, 1916, Congress made available for the President $20,000,000 for an "investigation of various methods for the production of nitrate and other products for munitions of war and useful in the manufacture of fertilizers." Investigations of conditions in this country and abroad resulted in a recommendation that the War Department take over the process of the General Chemical Company. This process was a modified form of the direct synthetic Haber process as practiced in Germany, but it had not been tried out on a commercial scale. Something had to be done, however, and the War Department erected Plant No. 1 at Sheffield, Ala., to test out the process. Only one unit of the plant was ever completed and difficulties encountered in operation showed that the process part of the plant would have to be remodeled.

Almost immediately after it had been decided to erect Plant No. 1, it was realized that an additional source of nitrogen should be provided for by a well understood and dependable method and a contract was entered into with the American Cyanamid Company to erect Plant No. 2 at Muscle Shoals, Ala., with an annual capacity of 40,000 tons of fixed nitrogen. The plant was completed and a successful test run made just a short time before the signing of the Armistice.

The wisdom of building Plant No. 2 can hardly be questioned as the cyanamide method was the only one on which the information available was sufficient for successful and undoubted operation. The method had been in operation at Niagara Falls, Canada, for several years and there was no doubt that it could be relied upon to fix nitrogen.

THE PRESENT NITROGEN SITUATION

Conditions since the close of the war, however, have changed greatly. Beginning in 1915 the study of the direct synthetic ammonia process at the Arlington Farm laboratory of the Bureau of Soils, the United States Department of Agriculture made its facilities available to the War Department in 1918. This earlier work was augmented with the establishment of the Fixed Nitrogen Research Laboratory. The development of catalysts and the acquiring of additional information on the process has been followed by the establishment in this country of a number of relatively small direct synthetic ammonia plants, but at least two companies, Lazote, Inc., and the Atmospheric Nitrogen Corporation have sufficient backing to develop the process on a large scale as occasion demands. The development of nitrogen fixation in this country has been almost exclusively with the direct synthetic method. No cyanamide plant is operated in the United States; the plant at Niagara Falls is on the Canadian side. The arc process is operated at one location in the West where power is cheap.

The trend in this country is only indicative of the development of the direct synthetic process throughout the world. There has been a continuous increase in the amount of nitrogen products coming from the direct synthetic method. The world consumption of inorganic nitrogen for the year ending June 30, 1927 was 1,315,000 against 1,206,000 tons last year and 1,088,000 tons the year before. By-product ammonium sulphate supplied 310,000 tons against 300,000 last year and 275,000 the year before. Synthetic nitrogen in different forms supplied 734,000 tons against 583,000 tons last year, and 450,000 tons the year before. Consumption of Chilean nitrate was 271,000 tons of nitrogen against 323,000 tons last year and 363,000 tons the year before. This shows that the increase in nitrogen consumption is being met largely by nitrogen fixation processes. As an illustration of the rapid development of the direct synthetic process, there were in the world in 1913, seven arc plants of capacity of 19,800 tons of nitrogen per year, fifteen cyanamide plants of a capacity of 66,000 tons and one direct synthetic plant of 7,700 tons, while at the close of 1918, there were twelve arc plants of a capacity of 41,800 tons, thirty-five cyanamide plants of 357,500 tons capacity and three direct synthetic with 338,800 tons. There are in 1927, operating or building, seven arc plants of 46,200 tons, twenty-eight cyanamide plants of 313,500 tons and forty-nine plants for direct synthesis of 770,000 tons capacity.

The trend of production of fixed nitrogen from the various sources may be seen from Table I, in which the world production for two years at the beginning of the World War and for 1920 and 1926 is shown. The production of Chilean nitrate shows a marked decrease for 1926, while that from direct synthetic methods is very greatly increased. The total estimated capacity of cyanamide plants in 1920 was about 325,000 tons, and for 1926 about 328,000 tons with a production in 1926 of 174,000 tons. Despite the difference between capacity and production of cyanamide plants, rapid construction of direct synthetic plants has taken place. The estimated capacity of these plants in 1920 was 311,000 tons, and in 1926 was 724,000 tons. The difference between capacity and production in these plants is mostly due to the construction of plants of such dimensions as to care for anticipated production in the near future.

TABLE I—WORLD PRODUCTION OF FIXED NITROGEN FROM VARIOUS SOURCES IN TONS

Sources	1913	1914	1920	1926
Chilean Nitrate	455,906	413,127	422,628	271,000
By-Product Ammonia	305,099	271,823	391,400	310,000
Cyanamide Process	35,838	44,035	130,000	174,000[1]
Direct Synthetic Processes	6,798	13,596	297,000	519,450[2]
Arc and Other Processes	19,800	23,000	42,130	40,550

[1] Total capacity of plants, 328,000 tons.

[2] Total capacity of plants, 724,000 tons.

In Table II are shown the percentages of nitrogen produced by the different fixation processes for the years 1913, 1914, 1920 and 1926, based on the total amount of nitrogen produced by atmospheric nitrogen fixation processes. The increasing relative importance of the direct synthetic methods and the decreasing importance of the other processes are clearly evident from these figures.

TABLE II—PERCENTAGE OF TOTAL SYNTHETIC NITROGEN BY DIFFERENT PROCESSES

Processes	1913	1914	1920	1926
Cyanamide	57.4	54.6	27.8	23.7
Direct Synthetic	10.9	16.9	63.4	70.8
Arc and Other	31.7	28.5	8.8	5.5

It may be readily inferred that the direct synthetic plants must possess some marked superiority over the other methods of nitrogen fixation. This superiority is mainly in the comparatively small amount of power required by the direct synthetic method, although the character of the product obtained offers some advantage.

The product obtained from the arc process is nitric acid. To make this available for fertilizer, it must be combined with some basic material and lime recommends itself as being cheap and suitable for addition to the soil. But the product, calcium nitrate, absorbs moisture and is a difficult material to handle because of the stickiness imparted when water is absorbed. This necessitates further treatment to overcome this undesirable property.

The product obtained from the cyanamide process is calcium cyanamide, a substance that can be used alone as a fertilizer under certain conditions with proper care. It is used thus in European countries on a rather extensive scale, but its use in this country has been in mixed fertilizer. It can be employed this way in only limited quantities in view of the fact that beyond a small proportion when mixed with acid phosphate it causes a reversion to insoluble phosphate. By additional treatment, however, other products may be obtained from cyanamide. Ammonia may be obtained by treatment with steam and the ammonia may be oxidized to form nitric acid. This nitric acid can be neutralized with an additional quantity of ammonia to form ammonium nitrate. Muscle Shoals Plant No. 2 is equipped to carry out all these operations. Ammonium nitrate is a desirable fertilizer material from the standpoint of nitrogen content as it contains about 35 per cent nitrogen, part as ammonia nitrogen and part as nitrate nitrogen. But it has the undesirable property of absorbing moisture from the air, so that special treatment is required for its use as fertilizer.

The product obtained from the direct synthetic process is ammonia, a gas at ordinary temperature and pressure. It is therefore necessary to combine it with some acid, or form some compound suitable for fertilizers. As ammonia may be derived from the cyanamide process as well as from the direct synthesis, the treatment may be similar from this point, or there may be a difference of treatment involving the use of carbon dioxide derived from purification of hydrogen in the direct synthesis method.

DEVELOPMENT OF NEW FERTILIZER MATERIALS

With the large production of ammonia from direct synthetic processes, studies have been made of the methods of utilizing the products as fertilizers, and many new forms of fertilizers have been suggested. Many of the compounds have been prepared and studied by the United States Department of Agriculture, but it is principally in Europe and especially in Germany that they have been produced on a commercial scale. If phosphoric acid can be produced cheaply, it may be used to combine directly with ammonia to form ammonium phosphate, a salt carrying both nitrogen and phosphorus and about 75 per cent of the weight as fertilizer constituents. Other products that it is possible to form, high in plant food constituents, are ammonium nitrate, calcium nitrate, potassium nitrate, urea, ammonium chloride, ammonium sulphate and potassium phosphate. By combinations of these it is possible to make fertilizer mixtures that contain the three principal fertilizer elements in varying amounts and in high concentrations. There are difficulties in the handling or keeping of some of the products, but methods of overcoming these difficulties are being rapidly developed, and it is probable that in the future with the increasing use of fertilizer and the decreasing production from the present sources of material, the strictly chemical fertilizer will form the basis of the fertilizer industry. This must await not only the development of the technology of manufacturing ammonia and phosphoric acid cheaply enough to compete with nitrogen and phosphorus in the present day fertilizer, derived from other sources, but must also await the education of the farmer to the use of new and unfamiliar materials. The most economical method must be employed to manufacture these materials and the history of nitrogen fixation shows the commercial displacement of the cyanamide process (the process of

Plant No. 2 at Muscle Shoals) by the direct synthetic process.

The manufacture of these new forms of fertilizer is dependent not only on the solution of technical problems, but on the economic situation. It is generally agreed that the development of the fertilizer industry is definitely toward concentrated materials. Definite knowledge must be available as to the properties and use of these materials before they will come into wide application. While the Department of Agriculture has been investigating the possible compounds suitable for fertilizers and the properties of these compounds and has tested their field application, there still remains very much to be done, before these concentrated fertilizers can be introduced into general practice in farming.

RELATION OF MUSCLE SHOALS PLANTS TO POWER

The association in the public mind of nitrogen fixation with power, and with fertilizers has led to the belief that the Muscle Shoals plants can be economically operated for the production of fertilizers because of the power available there. Nitrate Plant No. 2 at Muscle Shoals is a cyanamide plant and this method for fixation of nitrogen is already being rapidly displaced throughout the world by the direct synthetic methods. The consumption of power by the cyanamide process is about four times that of the synthetic processes. Plant No. 1 at Sheffield, based on the direct synthetic method, was designed for only one-fifth the capacity of Plant No. 2, and only a portion representing about one-fourth its capacity was ever completed sufficiently to make a test run. It was shown that this plant would have to be rebuilt to be operative. The cost of remodeling the plant would be considerable. In addition, the cost of power is not an important consideration in the operation of this process.

To operate Plant No. 2 at Muscle Shoals would be to utilize the power in fixing nitrogen by the process that is being rapidly displaced in the competitive markets of the world. To use the power for the operation of the direct synthetic process, it would be necessary to construct a plant based on the latest developments in this field, developments that have shown hydroelectric power unnecessary in its operation. The use of this power for the commercial operation of either process would be inadvisable, since it would employ it either in an uneconomic or an unnecessary manner and would prevent its utilization in processes where it is essential, or its distribution for industrial and domestic purposes. This is of real importance, for Muscle Shoals is so located that the demands upon its power, especially to the West and South, will undoubtedly increase.

Hydroelectric power is not necessary for nitrogen fixation by the direct synthesis method. This method employs the gases hydrogen and nitrogen and brings about their combination as ammonia under pressure, at a temperature of around 500° centigrade in the presence of a catalyst. In the first and largest plants of this sort, constructed in Germany, the hydrogen and nitrogen mixtures were prepared by the reaction of air and steam on coke in gas producers and purified before use for combination as ammonia. The principal power requirement is in the compression of the gases to several hundred atmospheres before they enter the reaction chamber, and this power can be obtained just as readily from coal as from water.

It is possible to obtain hydrogen from water by electrolysis and in this method electric power is necessary. However, the direct synthesis process when operated with electrolytic hydrogen requires about 20 per cent more power than the cyanamide instead of 75 per cent less when chemical means of producing the hydrogen are used. Hence the electrolytic hydrogen is used principally where it is obtained as a by-product from an electrochemical process as in the manufacture of chlorine. There are a number of places where waste hydrogen is being produced as a by-product and this hydrogen may be utilized in the direct synthesis process.

The possibilities in the production of ammonia make the situation somewhat uncertain but show a definite drift toward the use of coal in producing hydrogen. This makes it unwise either to tie up for a long time any considerable amount of water power in a process that is being rapidly superceded, or in using it in a process in which power is of minor significance.

The fact that nitrogen fixation is more closely allied with coal than with hydroelectric power makes it more important for the economical development of the industry that the plants be close to coal producing centers. Such locations also have the advantage of distributing the nitrogen fixation plants and from the standpoint of fertilizer distribution would be an additional saving in freight rates over that due to the production of the more concentrated products already referred to.

THE SITUATION AT MUSCLE SHOALS

At Muscle Shoals there is a large water power available, developed for use in fixing nitrogen by a process that at the time was well understood and dependable. This process is now being rapidly displaced throughout the world by the direct synthetic methods, in which hydroelectric power is not necessary. The power not necessary for nitrogen fixation will find a market in the rapidly developing public utilities and industries of the region.

Of the two plants at Muscle Shoals, Plant No. 1 is of small capacity and will require reconstruction to be put in operative condition on a process for direct synthesis of ammonia, and Plant No. 2 is a complete cyanamide plant of 40,000 tons nitrogen capacity, built as a war-time necessity, but tending toward obsolescence because of the rapid development of direct synthetic methods. The present day development of nitrogen fixation does not require hydroelectric power. In fact the industry is more closely allied to the coal industry than to water power.

The commercial development of nitrogen fixation plants in this country is taking place rapidly as evidenced by the establishment of a number of direct synthetic plants, and the projection of plans for other plants by two of the largest chemical manufacturing concerns in the country. Large amounts of new types of fertilizers from the nitrogen fixation products will not be produced, however, until the market develops for these materials; and the market must be developed through a campaign of education regarding the properties and use of the new materials. It is inevitable that the use of fertilizers will increase and the area of use widen, also that, with the present sources limited, the concentrated chemical products will form the basis of the future fertilizer industry.

Plans for the utilization of Muscle Shoals have ranged from private lease and operation of the power and nitrogen fixation plants to government ownership and operation of both; and from the separation of power and nitrate plants under private operation to the sale of power, and the operation of the plants by the government for experimental and educational purposes in developing the new forms of fertilizers. Whatever the solution of the problem is, it should take account of the ultimate demand for hydroelectric power in that region, the development of the nitrogen fixation industry in relation to power, and the development and introduction of the new fertilizer materials.

Nitrogen at Muscle Shoals

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IT is difficult to write regarding the Muscle Shoals project and confine oneself to the single aspect—nitrogen. This project has several truly national features which are from various points of view fully as important as is the nitrogen phase.

When Congress first authorized the location of a nitrogen fixation project and authorized the then President of the United States to make a selection of location for this project, there were at least four national characteristics thought of. At that time, the most important phase of the project, of course, was preparedness, or national defense. That aspect never, even in peace times, can be lost sight of. Then, taking second place in the category of national features connected with this project, was the production and distribution of fertilizers. It was then known, and has later come to be much better understood, that the same equipment down to a certain point in the process of manufacture which secures preparedness in the way of producing nitrogen, also makes it possible to secure fertilizers. A third feature which is connected with the Muscle Shoals project is that of river transportation. Too often, this aspect of the project is entirely lost sight of, but it is important enough in connection with the project to justify the statement that unless the Tennessee River is kept in mind throughout its navigable length as a transportation project, never can we expect the fullest development of fertilizer making at the Shoals.

The last feature and the least important from a national point of view is the power development at the Shoals. In the mind of Congress when the ordaining act was passed, power at Muscle Shoals was useful for one temporary purpose, only—that of preparedness, and for one permanent purpose, only—that of operating our preparedness and fertilizer factory in the locality of Muscle Shoals. Any separation of the power at Muscle Shoals from the preparedness and fertilizer aspects of the project is a departure from the ideas which evidently were in the Congressional mind when the soil was first broken at the construction period upon this project.

Unless one views, then, the Muscle Shoals undertaking in its broadest national way and from more than one point of view, it is difficult, if not impossible, to visualize its complete significance to our national life. It is an undertaking which in very direct ways in times of war or of peace brings rewards to each and every one of our citizens; but unless Congress views it in the broadest national way and not from one point of view, it may lose its entire national significance and become nothing more than a power station such as can be found in many other localities elsewhere in the nation.

TYPE OF LEGISLATION NEEDED

The practical thing for us to do at this time, then, is to consider what type of legislation we should have in order to secure for our entire citizenship the four national characteristics above set out, namely, preparedness, fertilizers, river transportation, and power. In considering this practical legislative side of the question, we find three groups which are advocating three somewhat diametrically opposed points of view before Congress. These groups are: the farmers who want private operation under an iron-bound contract that certain specific things at the Shoals will be done. Then, we find the governmental operationists who want Uncle Sam to operate the entire project at Muscle Shoals, and secure by that method of operation whatever benefits can accrue from the project. Finally, we have the power interests which have, from the beginning and quite naturally, wanted to have the operation of the project under their control so that there would be no competitive power offered for sale in the Southern territory.

The controversy revolves around the question of the fixation of nitrogen and the making of fertilizers, of course. Sometimes, the transportation and the preparedness aspects are either neglected or utterly forgotten. Never, though, is the power aspect of the situation either neglected or forgotten. In fact, the controversy is, in some ways, more of a wrangle for power than it is an advocacy for preparedness and fertilizer making.

NITROGEN FIXATION

The first activity, though, which all must consider at the Shoals if we want to begin at the bottom is the fixation of atmospheric nitrogen. Unless the project is made to operate in the fixing of nitrogen, the subsequent making of fertilizers cannot be expected and if the large national aspects of the projects are forgotten, we may expect that the transportation feature will be allowed to fall by the wayside, also. But in the matter of nitrogen fixation, we hear much these days about processes. In some ways, the arguments are made almost wholly in regard to the efficacy of the various processes for fixing atmospheric nitrogen. Truth to say, the Muscle Shoals enterprise has nothing to do with the quarrel as to which process is best or which is worst. In fixing atmospheric nitrogen at Muscle Shoals, we are faced with a business proposition more than a chemical and research one. Knowing that the cyanamid process will fix atmospheric nitrogen, the business proposition we necessarily must consider is this: Shall we junk the entire enterprise and let it degenerate into merely a power station, or shall we put the enterprise at work fixing nitrogen, first of all, and later manufacturing and distributing fertilizers?

Nitrogen fixation is comparatively, as all know, a new commercial undertaking. It is like most other business enterprises in that there is no one absolutely best method for fixing nitrogen. If there were some other process installed at Muscle Shoals than the cyanamid one, and if conditions for that other process, whatever it might be, were such as the process necessarily must have, then the business proposition facing us would be to make that process operative.

THE VARIOUS PROCESSES

The Muscle Shoals controversy now is not, when properly considered, a battle between and among the processes. More accurately, it is a battle for power, meaning whether the power shall be used to fix nitrogen and make fertilizers, or whether it should be distributed over transmission lines and sold at the prevailing kilowatt hour rates. It need not be maintained that the cyanamid process is greatly superior to any other known process, nor need it be asserted that any other process is so perfect as to eliminate every other method of nitrogen fixation. The so-called synthetic processes—the most commonly known one being the Haber and modifications thereof—are good and undoubtedly are proving themselves efficient where conditions are advantageous to their operation. One such condition necessarily must be cheap coal. If a Haber plant should be located in the anthracite coal region of Pennsylvania where coal is high in price, one might reasonably state that it would be uneconomic in its production of fixed nitrogen. Such location would not be an argument to maintain that the Haber process is obsolete—to locate a Haber plant in such environment would merely be to place a good process in a bad location.

If the cyanamid plant at Muscle Shoals had been located at Des Moines, Iowa, where power is not cheap and not available in large quantities except at high prices, the plant built on this location would be, as we state, "a fish out of water." Such a location in the case of the cyanamid process would not demonstrate that the process is obsolete, but merely that it was disadvantageously located.

What is meant by the above statements, briefly, is that various processes are good, but that each of them must be placed where conditions are suitable for its operation. A condition of a Haber process plant is cheap coal; a condition of a cyanamid process plant is cheap power. Since, then, we have a cyanamid plant where cheap power can be made available, provided such power be not transmitted for other uses over long distances, we may conclude that it is advantageously situated and can be made to operate comparably to other cyanamid plants in other parts of the world where such plants are located close to the cheapest power known which is hydro-electric power. At this time, however, the cyanamid plant at Muscle Shoals is the only such plant in the world idle, owing to the Congressional inability to make up its mind what to do with the entire Muscle Shoals project.

Those who advocate the beginning of operations at Muscle Shoals at Nitrate Plant No. 2 cannot be said to be opponents of any other process for nitrogen fixation which is known. Such persons can, however, be said to commend the cyanamid process which is installed at the Shoals for operation under conditions which that process must have to operate successfully in any part of the world. All who advocate the beginning of operations at the Shoals in the fixing of nitrogen and the making of fertilizers want a "free field and no favors." Neither tariff duties nor opposition to the introduction of other fixation plants in our nation are being advocated as methods to protect the operations at the Shoals. Muscle Shoals, when it begins to operate, must meet world competition in fixing nitrogen and in making fertilizers. If it cannot meet this world competition, it will have been proven to be an uneconomic venture. Such a development would be true no matter what process might have been installed in the beginning at the Shoals.

Referring to obsolescence which is so much heard of now in connection with nitrogen fixation, it may be stated absolutely that the only process which is obsolete is the one which cannot meet world competition. Thus far, neither the Haber nor the cyanamid process has been proven in this method of definition obsolete, for they are at the present time meeting competition of the entire world and greatly extending the sale of products made by the two processes.

THE CYANAMID PROCESS

But applying ourselves for a while more specifically to the cyanamid process since it is more commonly said to be obsolete and so described mostly by those who for various reasons do not care to see Muscle Shoals made operative except for power, let us see what the situation is relative to that process. Fifteen years ago, the total annual capacity of all the cyanamid plants in the world was only about 60,000 tons of cyanamid. Today, there are at least twenty-eight cyanamid plants all in operation in different parts of the world from which we have an annual tonnage of cyanamid somewhat in excess of 1,000,000 tons.

On the American continent, the fixation of domestic nitrogen began at Niagara Falls in Canada with an annual capacity of 5000 tons of cyanamid. The capacity of this plant has steadily grown until last year, 1925–26, the plant was producing at the rate of 120,000 tons of cyanamid per year. Down at Muscle Shoals we have a cyanamid plant about this same annual capacity which is, singularly, idle and is alone in that regard among cyanamid plants anywhere in the world.

In a recent month this plant at Niagara Falls, Canada, produced 11,000 tons of crude cyanamid or at the rate of 132,000 tons per year. This monthly production was equivalent to 2500 tons of nitrogen or at the annual rate of approximately 30,000 tons per year. This does not look much like obsolesence when we make comparisons of the above mentioned amounts with our importations of Chilean nitrates.

Taking the world's production of cyanamid of 1,000,000 tons annually, and using the very low yield of 17 per cent of fixed nitrogen, this gives 170,000 tons of fixed nitrogen as the world's annual production at all cyanamid plants. Our importations of Chilean nitrates are about 1,000,000 tons annually, yielding approximately 15 per cent of nitrogen. This gives us from our importations of Chilean nitrates 150,000 tons of nitrogen annually. We see, then, that the fixed nitrogen produced at all cyanamid plants in the world is 20,000 tons in excess of our total importations, annually, from Chile. In view of these facts, it is hardly possible to maintain that the cyanamid process is obsolete, for to do so one had as well maintain that Chilean nitrates are likewise obsolete.

The nitrate plant No. 2 at Muscle Shoals is by common acceptance now capable of producing 50,000 tons of fixed nitrogen annually. Since Chilean nitrates yield about 15 per cent nitrogen and with agriculture in the United States using about 660,000 tons of the Chilean products, annually, we find that we are importing for agricultural purposes about 100,000 tons of nitrogen, annually, from Chile. Since the plant at Muscle Shoals has an annual capacity equal to half this amount, it is inaccurate to claim that the Government's cyanamid plant at Muscle Shoals is obsolete or should any longer remain idle. It is a neglect of the national defense of the country and a disregard of the needs of agriculture that the plant has remained idle as long as it has.

INCREASED USE OF CYANAMID

Another approach to the question of obsolescence in regard to the cyanamid process is a study of the increasing use of raw cyanamid in the world. For instance, we find in a report issued by the Chemical Division of the United States Bureau of Foreign and Domestic Commerce the information that in 1913 Italy consumed 15,000 metric tons of cyanamid. This consumption had risen in 1926 to 86,000 metric tons. The Commercial Attaché of the United States at Brussels, Belgium, reports that for 1926 30,000 tons of Chilean nitrate, 25,000 tons of sulphate of ammonia, 32,000 tons of cyanamid, 4000 tons of nitrate of lime, 2000 tons of guano were imported and used in Belgium. These figures show a total consumption of nitrogen in Belgium of approximately 16,000 tons. Assuming that the 32,000 tons of cyanamid was of a reasonably high efficiency and carried 20 per cent of nitrogen, we find that nearly half of the total nitrogen imported into this nation was in the form of cyanamid. From a recent Moscow, Russia, publication, we are informed that the first atmospheric nitrogen fixation plant to be constructed in that country is to use the cyanamid process and will start out with an annual capacity of 10,000 tons.

IMPROVEMENT OF PROCESSES

Various nitrogen fixation processes have gone through the usual evolutions towards becoming more perfect in their operation. The Haber process now, undoubtedly, is more efficient than was the case in 1916. Its efficiency, under the conditions which it must have to be successful, is demonstrated by the increased production of the plants in various nations which have installed this particular process for fixed nitrogen. No doubt, the Haber process will, in future use, be developed beyond the point where it now stands. In the case of the cyanamid process an equal progress is noted. For instance, in 1910 the product of the cyanamid process in America contained not over 17 per cent nitrogen; in 1917, this percentage had increased to about 21 per cent, while at the present time the crude product before it is converted into fertilizer carries 23.5 per cent of nitrogen.

Further efficiency developments in the cyanamid process are found in the increase of furnace sizes which has meant a corresponding decrease in the power consumption per unit of product. Taking the power consumption in 1910 per unit of product as 100, the present consumption of power in 1927 in the large furnaces with improved control stands at 63. Stating this information in a different way, we find that in the earlier periods of production using the cyanamid process a short ton of nitrogen consumed about 3 horsepower-years. In 1912, the power factor per short ton of nitrogen had decreased to 2.5 horsepower-years. Tracing this development down to more recent years, we note that in 1916 Dr. Charles L. Parsons, at that time connected with the United States Bureau of Mines, stated as his opinion that the cyanamid process required 22 horsepower-years per short ton of nitrogen. In striking opposition to this very high estimate is the solid fact that the cyanamid process is now operating under American conditions with an average consumption slightly less than 2 horsepower-years per short ton of nitrogen.

Since the cyanamid process is one of mechanics more than of chemistry, the product can be secured on large scale operations with a minimum employment of labor. This, also, effects a great lessening of the cost factor in the final product. As compared to the production of synthetic ammonia, by using the cyanamid process, approximately two men of every three are eliminated, and the one man left is of that characterization known as the common laborer, whereas under the synthetic production of ammonia, the three men required are really technologists, and under American conditions would require to be paid very high wages.

Perhaps it is not necessary to give so much attention to the question of obsolescence, but if we are dealing with the question of nitrogen at Muscle Shoals, and it can be demonstrated that any particular process, cyanamid or otherwise, really is obsolete, we should at once eliminate that process from further consideration by Congress. Information such as just given, however, does not give strength to the assertion that the cyanamid process is obsolete.

HOW SHALL WE GET NITROGEN AT MUSCLE SHOALS

Now, the question is: What shall be done in order to get nitrogen at Muscle Shoals? The farmers are the only group which have had from the beginning a consistent nitrogen fixation-fertilizer program at the Shoals. Their program now, as it has been from the beginning, is in favor of leasing the project as a unit to a lessee, thus again committing the farmer to the idea that private operation is to be preferred over and above government operation of this or similar undertakings. Title to properties shall reside perpetually with the United States, and the duration of the contract shall be fifty years. Iron-bound terms must be in the contract which will require the lessee to reach maximum production in as short a time as possible and sell and distribute such production under the jurisdiction of a Muscle Shoals farmer board. The products to be made at the Shoals shall be such as will carry not less than 40 per cent plant food, and there must be no separation of power available at Muscle Shoals from the fixation of nitrogen and the making of fertilizers. The Government must be protected in this contract in regard to payments, both amortization and interest, so that in time it will recover from the lessee the reasonable peace-time costs of the project and still retain title thereto. All this and more is incorporated in the Madden bill, H. R. 441, 70th Congress.

Any proposal which deviates from the above fundamental features of the lease can be accused of not carrying forward the original intent of the Congress when the Muscle Shoals project first was authorized, and assuredly can be criticized as being not what the farmers desire from this great undertaking.

The Public Service of Muscle Shoals

By Mrs. Harris T. Baldwin

Chairman, Committee on Living Costs, National League of Women Voters

MUSCLE SHOALS is a war legacy. Before 1916 our chief source of supply of nitrates needed in the manufacture of munitions was Chile. It was thought that if we entered the World War we should have some means of producing those nitrates in this country. The National Defense Act was passed June 3, 1916. Clause 124 of that Act authorized the President to select one or more sites in this country where cheap water power could be developed for the purpose of extracting nitrogen from the air. The nitrates produced were to be used for munitions in time of war and in the manufacture of fertilizers and other useful products in time of peace. The Act further provided that the plants should be operated solely by the Government and not in conjunction with any other industry or enterprise carried on by private capital.

President Wilson chose the Muscle Shoals at Florence, Alabama, on the Tennessee River. Power was needed for construction work, and the first thing done was to enter into a contract with the Alabama Power Company, which had a steam plant at Gorgas, the mouth of a coal mine, 90 miles south of Muscle Shoals. The plan of work at Muscle Shoals called for three dams, two navigation dams and one power dam, two nitrate plants, two electrical steam plants, power house, lock, industrial village, and the purchase of a large tract of land and the Waco lime quarry. When the armistice was signed in 1918, $105,000,000 had been expended, two nitrate plants and the steam plants were completed and some work had been done on the power and navigation dams. The immediate need for nitrates was passed, and so the question of the disposition of Muscle Shoals came before the Congress.

CONGRESSIONAL ACTIVITY ON MUSCLE SHOALS

To go into the detail of Congressional activity since 1918 would take far too much time and space. Each year several proposals have been presented to Congress without success. In the spring of 1925 President Coolidge appointed five men to serve on a Muscle Shoals Commission. The duty of this Commission was to assemble reliable information for Congress as to the production of nitrates and to report not later than November 15, 1925, upon the most practical method of utilizing the nitrate plants to the best advantage. During the first session of the 69th Congress four bills and one resolution were introduced. By the passage of the House Concurrent Resolution No. 4 in March, 1926, a joint committee on Muscle Shoals was created. This committee was composed of three members from the Senate Committee on Agriculture and Forestry and three members of the House Committee on Military Affairs. They were authorized to conduct negotiations for a lease or leases of the properties at Muscle Shoals and in April, 1926, they recommended a proposal by thirteen allied power companies and submitted a bill embodying this offer.

The first and second sessions of the 69th Congress adjourned without taking any action on this bill, and the problem of Muscle Shoals remains unsolved.

In the meantime, however, Congress has made provision for continuing construction work on the dams and power house. In 1918 the preliminary work at Wilson Dam such as construction of camp, roads, railroads and coffer works was begun together with the purchase of supplies and equipment. This work was stopped in August, 1918, by order of the War Industry Board and resumed in November of that year. Work on the lock and dam and power house was continued until June, 1921, when because of lack of funds it was gradually shut down until it was practically on a maintenance basis, and it was not until the fall of 1922 that funds were available to actually resume work.

Wilson Dam and the power house were completed in 1925, and the first generator to be put under load was in September of that year. This work has been done under the supervision of army engineers.

LEAGUE OF WOMEN VOTERS AND MUSCLE SHOALS

Since 1921 the National League of Women Voters has had Muscle Shoals on its program. For five years the League studied it carefully from all angles. And in the Convention of 1926 the League went on record as favoring Government operation of Muscle Shoals.

It has been my privilege within the last month to be one of the two members of the National League of Women Voters to visit Muscle Shoals. For six years we have attended the Congressional hearings, we have sat in the gallery of both the House and the Senate and listened to the debate on the floor, we have read everything available and have talked to many people regarding its disposition. Within the last year statements have been made which have in part contradicted much that we had read. We were told that Muscle Shoals was in a run-down condition, going to rack and ruin, that rust was the predominating color at the nitrate plants, that the potential power there was of no importance to the South. In fact one of our League members living in a southern state received with her October electric light bill a flier which read in this manner: "Do not believe all you read and hear about Muscle Shoals; there is not power enough there to supply more than one small town." We decided to go and see for ourselves.

There was no rust. It came to us forcibly when we first stepped into one of the buildings of the nitrate plant No. 2. For nearly ten years the machines have stood idle, yet each was cleaned, polished, oiled. The only rust we saw was on a small scrap heap which had been dumped from some other war activity and which the Army Engineer in charge of Muscle Shoals had no authority to move. We looked for signs of deterioration and ruin, and were only conscious as housekeepers that Uncle Sam knew how to keep property under his care in excellent condition.

Our first desire was to see Wilson Dam and the power house, and to check up on the statement that the power developed there was of no great importance. It would be impossible to describe the physical structure of Wilson Dam. To a woman it seems nothing short of a miracle that human hands working against such odds could build it. The mere mathematics of it are almost beyond her ken. What she can understand, however, are the possibilities of such a project once it is finished.

Power from Muscle Shoals

It was in the power that our great interest centered, because we had a vision of what power from Muscle Shoals might mean to the homes in that region. While we wait for Congress' decision some power is being generated and sold to the Alabama Power Company. Eight units in the power house are ready to be put in operation and there are wheel pits for ten more units. Not more than four units have been in operation at a time. We learned the "flier" to the contrary that it was not because of lack of power, but because of the inability of the Alabama Power Company to take it away. According to the figures of the Army Engineer in charge the capacity of the Alabama Power Company transmission lines from nitrate plant No. 2 is 120,000 kilowatts with normal line losses, and this capacity can be increased to 130,000 kilowatts by overload.

We were given to understand it would cost the Alabama Power Company several million dollars to build transmission lines capable of taking away the power which can be developed. One reason why this has not been done is because with the fate of the Muscle Shoals still undecided no long-time contract may be made. Hence, on thirty days' notice the Government can stop selling power. For this power which the Government sells the Alabama Power Company pays 2 mills a kilowatt hour—it is sold in Alabama up to 8 cents a kilowatt hour.

These are the figures given us by the Army Engineers on the revenue received from the sale of electric energy generated at Wilson Dam from September 12, 1925, to October 31, 1927:

September 12 to October 31, 1925..	$73,453.37
January 1 to December 31, 1926...	872,617.47
January 1 to October 31, 1927....	1,020,535.78
Total....................	$1,966,606.62

During the operating period in 1925, the hydraulic and electrical machinery was being tested and it was impracticable to run more than one unit at a time, and operation was intermittent, due to the necessity of changing connections, making adjustments, etc. The testing continued to March 31, 1926, but four units were available after December 31, 1925. April 1, 1926, is taken as the date on which the plant was placed in commercial operation.

No power was sold from July 5 to 15 inclusive, 1926, during which time a new agreement was under consideration by the War Department and Alabama Power Company.

The money received from the sale of power is deposited in the Treasury of the United States as "miscellaneous receipts."

It is interesting to compare the annual revenue from three or four units at 2 mills per kilowatt hour with the best power bid which has as yet been submitted. If the Government accepted this bid it would receive during the fifty years of the lease $600,000 per annum for six years, $1,200,000 per annum for the next six years, $1,500,000 per annum for the next six years and $2,000,000 per annum for the remaining thirty-two years.

We were intensely interested in the figures of Mr. J. C. Stiles, who is engaged in power study work under the district engineer at Florence, which showed the relative output of electric energy in several southern states. According to his figures the public utility companies in the state of Alabama, including Wilson Dam, produced in 1926 1,582,717,000 kilowatts; in Georgia, 710,578,000 kilowatt hours; in Mississippi, 58,667,000 kilowatt hours, and in Tennessee, 894,015,000 kilowatt hours. The kilowatt hours produced at Wilson Dam during that period were 436,308,735 kilowatt hours. Mr. Stiles figures that Wilson Dam is capable of producing from 1,500,000,000 to 2,000,000,000 kilowatt hours per annum.

Muscle Shoals has a weak spot which must be considered. The flow of the river is far from constant; it varies with the seasons; the primary power in round numbers is 100,000 horsepower. Yet at times of the year enough water goes over the dam to make a million horsepower. There are two ways of equalizing the flow: by storage dams and by supplementary power from steam plants. Already estimates have been made for a second power dam at Cove Creek on the Clinch River. If this were constructed it would double the primary power at Wilson Dam.

GOVERNMENT OPERATION OF MUSCLE SHOALS

One of the reasons underlying the League of Women Voters' stand for Government operation of Muscle Shoals was the feeling that Muscle Shoals and the Tennessee River should be developed as one project, that there are three phases of such project, power, flood control, and navigation. The Tennessee River flows through the heart of the South. In its unimproved state it is not navigable. Senator Norris of Nebraska writing in "The New South," July, 1927, says regarding navigation, "In order to secure to the people of the South the use of their own property, it was proposed in Congress that the Government should make a complete survey of the Tennessee River and all its tributaries, and that there should be built from time to time during the next ten or fifteen years, a network of dams for the improvement of navigation, the control of flood waters, and the development of electricity. It is only by dealing with a system of this kind we can get the maximum amount of benefit from the minimum cost."

AID TO NAVIGATION

An attempt to aid navigation in a small way has been made at Dam No. 1, which is a navigation dam. Dam No. 3 is to be a navigation dam also, but work has never really been started on it. The chief of engineers has stated that $9,000,000 is a fair assessment for the benefits to navigation of Dam No. 1, and the President's Muscle Shoals Commission estimated $10,000,000.

Wherever Muscle Shoals is discussed there is always the cry "cheap fertilizers for the farmer." It has come almost to be a political slogan. There are those who think that the power at Wilson Dam should be used exclusively for the manufacture of fertilizers in time of peace. They think that if the nitrate plants are leased Wilson Dam should be included and if there is excess power it may be sold by the lessee. There are others who feel that it is a questionable thing to lease on those conditions. It has never yet been satisfactorily proven that cheap fertilizers can be produced at nitrate plant No. 2.

At the time the National Defense Act was passed it was generally believed that by the use of cheap power we would be able to take nitrogen from the air at a cost that would lessen the cost of fertilizer.

The Arc process was the first method used to take nitrogen from the air; it required a great deal of cheap power. The cyanamid process was discovered to take much less power. It was known that the Germans were working on a method said to be a great improvement over the cyanamid process. This was known as the Haber process. While the details of this process were not fully understood, still the experts thought there was a chance to construct a plant using this process to extract the nitrogen from the air. Nitrate plant No. 1 was in the nature of an experiment and was a total failure.

The building is supplied with a steam plant and can be used for other commercial purposes. Since the war, however, we have learned the details of the Haber process. Constant improvement is being made, and with every new improvement less and less power is needed. Today anyone constructing a nitrate plant locates it near the source of cheap coal rather than water power.

Nitrate plant No. 2 is constructed to extract nitrogen from the air by the cyanamid process. It is capable of extracting 40,000 tons of nitrogen from the atmosphere in a year. The process is not obsolete, but experts say the time is not far distant when it will be. The American Cyanamid Company has submitted a bid for nitrate plant No. 2 which includes Wilson Dam.

Are we going to sign away our property for fifty years? Are we sure that the American Cyanamid will produce a fertilizer which will be cheap for the farmer? Is it not possible that within a period of fifty years experimentation in the manufacture of nitrates will reach the place where very little power will be used even in the cyanamid process? Who will get the benefit of the sale of the surplus power from Wilson Dam, and is the rental which the Cyanamid Company offers large enough to repay us for investing about $160,000 and for giving up our property for half a century?

The late Walter Durand in his last article called attention to the "need for public yard sticks" by which public and private ownership of power enterprises might be measured. We are constantly being told that public ownership will not work. We have no great public power enterprise and therefore no means of comparison, and the National League of Women Voters feels that Muscle Shoals rightly developed could be used as a "public yard stick."

Book Department

Latané, John H. *A History of American Foreign Policy*. Pp. xiv, 725. Price, $4.00. Garden City: Doubleday, Page and Company, 1927.

The general interest in questions of international relations since the World War and the new courses being offered on that subject in our universities and colleges have been recently met by a number of volumes which attempt to present the foreign policy of the United States as a continuous development from its beginnings to the present day. The volume before us is the latest of these, and it will receive a cordial welcome from the public at large as well as from academic circles. For it is not only a scholarly treatise, such as might have been expected from one of the author's professional standing, but is at the same time an unusually readable story, told in easy narrative form, made graphic by the introduction of numerous quotations from documentary material, and interspersed with the author's comments and occasional vigorous criticisms.

A History of American Foreign Relations might perhaps be a more descriptive title. For the volume covers all of the important incidents in the diplomatic intercourse of the United States and introduces a number of topics and much historical detail which could scarcely come under the head of "Foreign Policy" if by that title is meant the principles which more or less consistently have guided the United States in its relations with other states. The chronological method, inseparable from a history, is relieved by a topical treatment consisting of six periods, each marking a new trend in our foreign relations. "Republican Principles and Ideals" covers both the French Alliance and the policy of neutrality. "Defiance of the Old World" includes the struggle for neutral rights and the announcement of the Monroe Doctrine. "Rounding Out Seas and Looking Over Borders" deals with territorial and commercial expansion and the opening of the Far East. "Safeguarding the Union" is concerned primarily with the diplomacy of the Civil War, while "Expansion in Caribbean and Pacific" and "Intervention in Europe" take up the more recent phases of American diplomacy.

Among the many judgments which the author expresses upon men and events it is interesting to note his defense of Jefferson's position in 1793, his legal justification of the Louisiana Purchase, his criticism of the anti-slavery tradition with respect to the annexation of Texas and the Mexican War, his defense of the Clayton-Bulwer Treaty, and, coming down to more recent times, his sharp criticism of Secretary Hughes' policy towards the League of Nations. The survey of the events leading up to American participation in the World War and of the attitude of the Senate towards the League of Nations is written with a conscious effort at impartiality, although it is clear on which side the sympathies of the author lie. A closing chapter asserts that the present policy of "Coöperation without Entangling Alliances" is "an empty formula" and "a species of camouflage," and points out that both the economic rehabilitation of Europe and the problem of disarmament are fundamentally political questions.

The typography of the volume is quite equal to its contents. The marginal headings are an undoubted help to the student, and the blocking of direct quotations from documentary material will be of great assistance to teachers in using the volume as a basic text. Professor Latané's volume is destined to have a wide circulation in our universities and colleges and it is to be hoped an equally wide circulation outside of academic halls in view of the urgent need for accurate and unbiased information upon American foreign policy in the light of its past traditions.

C. G. Fenwick.

Saenz, Moises and Priestley, Herbert I. *Some Mexican Problems*. Pp. ix, 174. Price, $2.00. Chicago: The University of Chicago Press, 1926.

These six lectures on Mexico were delivered during the summer of 1926 before the

Third Institute on the Harris Foundation at the University of Chicago. The first three deal with the Program of the Mexican Government and were delivered by Señor Moises Saenz, Subsecretary of Education of Mexico. The last three lectures are by Herbert I. Priestley, Librarian at the University of California, author of the best recent history of "The Mexican Nation" (1923), and an acknowledged authority on that country.

This small volume contains a keen critical analysis of present conditions in Mexico. Its discussions of the recent relations of the United States with its southern neighbors are most enlightening. Señor Saenz maintains that there has been but one revolution in Mexico since 1910—the continuous fight of the landed aristocracy against the people, of "privilege against destitution." He shows the marked progress made by labor in his country under the influence of the American Federation of Labor. His discussion regarding the influence of American capital and commerce in Mexico tends, however, to be an *ex-parte* statement; it leans toward nationalistic resentment rather than scientific accuracy.

Dr. Priestley's discussions are masterly—neither fulsome praise nor passionate condemnation of American policies. They supplant the querulousness of diplomatic legalisms with a warmth of neighborly respect and admiration.

HARRY T. COLLINGS.

RIPLEY, WILLIAM Z. *Main Street and Wall Street*. Pp. v, 359. Boston: Little, Brown and Company, 1927.

It is only seldom that the vituperative pen of a college professor creates the commotion which was aroused in financial and official circles by the publication of the series of articles on corporate practices which first appeared in the *Atlantic Monthly* and which were subsequently expanded into the present volume. Members of the New York Stock Exchange literally "sat up and took notice." The Interstate Commerce Commission, in several of its recent decisions, has heeded the note of warning sounded by Professor Ripley, while the Committee on Industrial Securities of the Investment Bankers Association of America has publicly expressed its disapproval of some of the corporate machinations elucidated so forcefully in *Main Street and Wall Street*. In the words of the author "such immediate and well-nigh unanimous response to but a slight stimulus is perhaps unique in our economic annals." It reflects not only a growing consciousness of the existence of unsocial tendencies in modern corporate activity, but more interestingly reveals the fact that the modern college professor can and does at times step out of his proverbial rôle of groping abstract theorist to hold up the mirror to the grim realities of life.

Main Street and Wall Street makes decidedly entertaining as well as profoundly instructive reading. Even though we may be inclined to minimize the importance of voting rights to the average stockholder and to deprecate the significance of divesting ownership from control in modern corporate procedure, the fact remains that the author has rendered a very timely service by inquiring "deeply concerning those things which might better serve the common good than is now the case."

KARL SCHOLZ.

TARDIEU, ANDRÉ. *France and America: Some Experiences in Coöperation*. Pp. viii, 312. Price, $3.00. Boston and New York: Houghton Mifflin Company.

M. Tardieu, in this excellently written book, presents a picture of the relationship that has existed between his country and America since its founding. Remarkably unbiased in his point of view, he applies to the problem his extensive knowledge of American political and social institutions and habits of mind. He shows clearly, insistently, that the two races, so opposite in historic traditions, in ideas of government, in temperament, have much to offer each other in the way of mutual help and understanding. The problem of tomorrow, he says, is the proper ordering of Franco-American friendship that it may be fruitful.

The war brought into close contact two countries that are potential enemies; since 1918, however, the gap has again widened rather than lessened. France, concedes Tardieu, has as frequently taken the wrong course in her dealings as has the United

States. It is necessary that she borrow some of America's optimism, that she group her forces rather than her weaknesses, that she put herself on a footing of equality with the United States. America, on the other hand, must become more human, must cultivate greater commercial tact, must commit fewer errors of judgment and action. Each country must learn to know the other better.

The book is conceived along optimistic lines. Tardieu is convinced by reason and by experience of the coming enlightenment for which he pleads.

DOUGLAS L. HUNT.

SAIT, EDWARD M. *American Parties and Elections*. Pp. vii, 608. New York and London: The Century Company, 1927.

This book starts off with a discussion of manhood suffrage and registration, Negro suffrage in the South, woman suffrage, and organized groups and public opinion. The author justifies this on the basis of a statement that these are the instruments of the party. He then turns to the nature and history of parties, party organization, nominations, and finally again to elections. The text is replete with citations and numerous and pertinent quotations from the sources. The style is clear and interesting. The book is useful as a textbook for universities, but also as an interesting handbook for the many newer voters of the country who are anxious to learn the ways of politics and politicians.

CLYDE L. KING.

ENGELMANN, GEZA, PH.D. *Political Philosophy*. Pp. xxiv, 398. Price, $3.00. New York and London: Harper and Brothers, 1927.

This is the translation of a book by this title written by the Hungarian scholar, Doctor Geza Engelmann. The translator is Doctor Karl Frederick Geiser, Professor of Political Science in Oberlin College. Introductory notes have been added written by Professor Oscar Jaszi, giving the background of the times in which each of these authors lived, with the exception that the introduction on Hamilton, Madison and Jay was written by Doctor Geiser.

This is not a résumé of the more important theories of the classical political scientists, nor is the book made up of excerpts of the original text with comments and footnotes. On the contrary, Doctor Engelmann presents what he finds to be the essence of the theories of fifteen of the greatest philosophers of the State. The leading and creative ideas of each philosopher are given. In his own footnote Doctor Engelmann said that his aim was "not to interpose my own ideas in a way that might seem inappropriate or disconcerting, but rather to arrange and formulate their thoughts clearly and concisely, as if the masters themselves were presenting, in a brief discourse, whatever in their teachings is of importance to us—their legacy to us."

The political scientists whose works are thus presented are Plato, Aristotle, St. Thomas Aquinas, Dante, Machiavelli, Thomas More, Thomas Hobbes, Baruch, Spinoza, John Locke, Charles de Secondat, Baron de Montesquieu, Jean Jacques Rousseau, Alexander Hamilton, James Madison, John Jay, and Jeremy Bentham.

CLYDE L. KING.

OGBURN, W. F., and GOLDENWEISER, A. *The Social Sciences and Their Interrelations*. Pp. viii, 506. Price, $3.50. Boston: Houghton Mifflin Company, 1927.

The development of specialized social sciences from "the metaphysical cradle of Mother Philosophy" has been accompanied by such an intellectual division of labor that synthesis as well as analysis has now become necessary. The student within a particular field becomes so engrossed with his specialty that its relationship to the general field of the other social sciences is apt to be obscured.

Although the task of an Aristotle, or even of a Herbert Spencer, in the synthesis of all knowledge seems difficult to imagine today, it does seem possible and desirable occasionally "to beat the boundaries" of the different social sciences and to glimpse as a whole the "no man's lands" of social science. To see the interrelationships of the different social sciences and to discover the effects of recent developments within each social science on all the others is the ambitious purpose of this new book of Professors Ogburn and Goldenweiser.

The social sciences are divided into five grand divisions. In the first portion of the book the relationship of anthropology is traced to each of the other social sciences. Then follow, in turn, discussions of the relationship of economics, of history, of political science and of sociology to each of the other social sciences. There is an introductory chapter on the general field of the social sciences and a concluding section on the relations of the social sciences in general to such allied fields as biology, education, the natural sciences and philosophy.

As each chapter is written by a different author, some duplication and a lack of continuity are inevitable. Moreover, there are certain apparent differences in method of treatment and in the value of the various contributions. Again, the editorial pressure to compress within one small book this enormous field has resulted in many brief statements, which call for expansion, and certain general statements, which require further explanation.

The reviewer would not presume to pass on the "correctness" of the divergent points of view of the numerous authorities in these many divergent fields. Such a clash of opinion is to be desired as well as to be expected. Therein lies one of the chief merits of the book.

The authors of the different chapters are leaders within their respective fields. The editors are to be congratulated on having secured the coöperation of such a group of social scientists. The national and international reputations of the contributors to this volume make it deserving of the study of all teachers and advanced students of the social sciences.

The Social Sciences may perhaps be described as an orientation textbook for all graduate students in the social sciences. Although open to many criticisms—chief of which is that it has attempted the impossible—this book makes a real contribution in itself, as well as pointing the way toward a more comprehensive and intensive synthesis of the social sciences.

S. HOWARD PATTERSON.

KILBORNE, RUSSEL DONALD. *Principles of Money and Banking.* Pp. vii, 559. Price, $4.00. Chicago: A. W. Shaw Co., 1927.

Professor Kilborne has in a single volume essayed to cover an extensive field. The book is divided into four parts, one on Money, another on Foreign Exchange, another on Commercial Banking and the Federal Reserve System, another on Non-Commercial Banking. Under the last heading there are chapters on Trust Companies, Savings Banks, Investment Banks, Investment Trusts, the Federal Farm Loan System, and the Federal Intermediate Credit System. The broad scope of the work leads to its chief defect. To compress his material within the limits designed, Professor Kilborne has been forced apparently into a rather didactic treatment. Principles are set forth without sufficient demonstration to make them entirely clear, and occasionally controversial matter is presented in a positive way as though it were a statement of fact. For example, on page 93, "While the national banks are still allowed to issue notes, the issue function *will within a short time* be granted only to the Federal Reserve Banks." No doubt that is the hope of most students of currency problems; it may even be highly probable, but whether it will occur within a short time depends upon the action of the government when the bonds securing the currency mature.

The author explains his method of treatment by pointing out in his preface that he is emphasizing fundamentals and principles rather than facts and structure. Although the work contains no original contribution to monetary and banking theory, it is clearly written and its subject matter is logically developed. It should be of value to those who desire to obtain a general picture of a broad field without delving deeply into any part of it.

W. CARLTON HARRIS.

GARIS, ROY L. *Immigration Restriction.* Pp. xv, 376. Price, $4.00. New York: The Macmillan Co., 1927.

Professor Garis has attempted a history of the development of "the opposition to and the regulation of immigration into the United States." It was not his purpose, however, "*to judge the merit and truthfulness* of the causes of the opposition and legislation" (p. xi).

This is to be regretted, for throughout the study he gives the impression of taking the position that any sort of restriction legislation is better than none. It would seem that in a history the author should refrain from constantly praising any given policy unless sufficient evidence is included in support of such an attitude. There is no adequate analysis of the economic, social or biological effects of immigration, yet there is assumed an urgent need for legislation to prevent the immigrant from swamping our industries, disrupting our government, filling our jails, hospitals and almshouses and lowering the biological qualities of our population. Perhaps the writer's approach is in a way indicated by an isolated illustration. In partial support of his statement that "For America, the Japanese are a nonassimilable people, as are all Asiatics . . .," he quotes the two lines from Kipling beginning "East is East . . ." (p. 353).

In spite of this bias, *Immigration Restriction* is a most valuable study. The development of the restrictionist policy (as a restrictionist sees it) from Colonial times to the present is clearly presented though much is necessarily omitted. All important immigration legislation is admirably summarized. Special chapters deal with Chinese and Japanese immigration. The brief foreword by the Honorable Albert Johnson, Chairman, Committee on Immigration and Naturalization, House of Representatives, whose immigration policies are well known, strikes the keynote for the volume.

DONALD YOUNG.

McCOMBS, CARL E. *City Health Administration.* Pp. 524. New York: The Macmillan Company, 1927.

The author, in the preparation of this volume, has aimed to present a non-technical treatise on municipal health administration. An introductory section considers, first, the place of municipal health service in the field of public welfare, and, second, the administrative relations of the preventive and curative health functions. Great emphasis is placed upon the advantages to be derived from the consolidation of all health and welfare functions in a single department with a competent administrative head. A second section, comprising fully two-thirds of the volume, deals with the organization and administration of sickness preventive functions, certainly the larger and more important aspect of the municipal health service. Subjects under this section which chiefly engage the attention of the writer are the problems of personnel, functional organization, vital statistics, food and sanitary inspection, health education, and finance. A final section, dealing with the organization and administration of sickness treatment functions, analyzes numerous problems arising in connection with municipal hospital service.

Dr. McCombs has rendered a valuable service in making available the results of numerous municipal health surveys. The work is comprehensive and authoritative. The author's wide experience, which has brought him into close contact with actual situations, militates against any tendency on his part to become dogmatic in his discussion of principles. There can be little question but that this is the best treatment of municipal health service in the United States that has as yet appeared. The volume contains an excellent bibliographical accompaniment.

MARTIN L. FAUST.

YOUNG, ALLYN A. *Industrial Combinations and Public Policy.* Pp. 331. Price, $2.50. New York: Houghton Mifflin Co., 1927.

This book dealing with one of the most important of modern economic problems is equally well suited for use as a text for courses in Trusts and Monopolies and for the purposes of the general reader. The book meets the claims made for it in the Editor's Introduction, where it says that "the tone of the book throughout is that of thoughtful and candid discussion."

In his treatment of the subject, *Industrial Combinations and Public Policy,* the author gives the combination movement its historical setting; analyzes its general economic aspects; appraises carefully the results of combinations in a number of important industries; and then at the end there is a judicious balancing of the various considerations that help to determine what public policy should be. There are different types of industries, however, and no single system of control will work well throughout the whole field. The criteria which set apart the different types of industry are examined, and reasoned conclusions are reached with respect to the method of control which appears to be best adapted to each type.

W. C. PLUMMER.

WELD, W. E., and TOSTLEBE, A. S. *A Case Book for Economics.* Pp. xiii, 508. Boston: Ginn and Company, 1927.

VANDERBLUE, H. B. *Economic Principles: A Case Book.* Pp. xvii, 670. Chicago: A. W. Shaw Company, 1927.

New college texts in economics have been numerous, but real pioneers have been rare. There are many texts on economic principles, on economic problems, and on economic principles and problems combined. There are also several collections of readings in economics and also several excellent books of questions and exercises based on various standard texts. But an unfilled need, often expressed at meetings of the American Economic Association, has been for a case book for teachers of economics who desire to follow this particular method of presentation. At last, the tools for teaching economics by the case method have been provided by the publication of the two books under review.

After an examination of these excellent texts of Professor Vanderblue and of Professors Weld and Tostlebe, the reviewer is still uncertain as to just what constitutes a case book in economics. How does it differ from a live book of readings, well selected, carefully pointed toward certain educational objectives and with leading questions appended to each selection? Although there are many first-hand cases taken from actual industry, which give these books a realistic flavor, there are also many mere descriptions which differ little from those found in a good book of readings. Indeed, the first "case" in Professor Vanderblue's book is the classical illustration of division of labor, which is taken from Adam Smith's famous picture of the manufacture of pins. Although the reviewer knows of no better description of division of labor than that of Adam Smith, does this constitute a "case"?

The case book of Professor Vanderblue seems more adapted to the needs of advanced students, and that of Professors Weld and Tostlebe more suitable for less advanced students of economics. Again, the arrangement of Professor Vanderblue's book seems more logical. At least, it conforms more nearly to the generally accepted plan of organization. It follows rigorously that of Professor Taussig, and the assumption is that the student will read the corresponding chapters of the latter's "Principles of Economics." Nevertheless, each chapter of Professor Vanderblue's case book contains specific references to most of the other standard texts on economic principles. It is also well indexed and contains an appendix consisting of an alphabetical list of cases in addition to the logical enumeration of cases contained in the table of contents. On the other hand, the case book of Professors Weld and Tostlebe contains neither an index nor references to general texts on economics. The suggestion is made that, "The cases may be used in any convenient order and with any of the textbooks."

It is not part of the reviewer's task to discuss the advantages and disadvantages of teaching economics by the case method, which has long been the favorite method of teaching law. It is merely his pleasant function to announce that there are now available in book form materials for the teaching of economics by this method. Actual classroom experience alone will demonstrate the possibilities and limitations of teaching economics by the case method.

S. HOWARD PATTERSON.

BECKER, CARL. *Our Great Experiment in Democracy.* Price, $3.00. Pp. ix, 332. New York and London: Harper and Brothers.

This is a reprint, with slight revisions, of the author's "The United States: An Experiment in Democracy," first printed in 1920. The book deals in a most interesting fashion with America and democracy, the origins of democracy in America, the new world experiment in democracy, democracy and government, new world democracy and old world intervention, democracy and free land, democracy and slavery, democracy and immigration, democracy and education, and democracy and equality.

What the author of the book calls the publisher's "blurb" on the jacket in which the publisher says that the book gives "a clear, honest, and brilliant picture of the United States as a democracy from the first Continental Congress down to the Harding Administration" is a fair statement of the style and contents of the book. The point of view of the book is expressed in the following quotation: "Political democracy we have; but the old economic democracy is rapidly becoming a thing of the past. To achieve, under these changed conditions and by new methods, the economic freedom without which political freedom is of little use is the task of the coming years."

Clyde L. King.

Cleveland, Frederick A. *American Citizenship as Distinguished from Alien Status*. Pp. 464. Price, $4.00. New York: The Ronald Press, 1927.

This volume appears as the first of a series to be published by the Department of Citizenship of Boston University in partial fulfillment of the University's obligation under the Maxwell Foundation. The purpose of this book, as stated by Doctor Cleveland, is to set forth what the citizen's relation is to the community by means of a scientific presentation of the facts which it is thought each American citizen and each "stranger within our gates" should know about his status. The twenty-one chapters into which the development of the subject is divided are grouped under the heads of "Citizens as Members of Political Society," "Citizens and Aliens as Beneficiaries," and "Citizens and Aliens as Subjects." Three chapters, VIII, IX, and X, are acknowledged as comprising substantially the same material as was submitted for a Master's degree thesis by an associate in the Department of Citizenship.

While Doctor Cleveland states in his preface that the volume "undertakes to set forth in clear and orderly terms the meaning and implications of American Citizenship as defined in the constitutions of the nation and the states, in statutes, the decisions of courts, and the utterances of government officials," he proceeds to ignore official documents almost entirely and to assemble his facts for this undertaking to a great extent from secondary sources, frequently in the form of lengthy quotations and very unfortunately, in several instances, from works which have been rendered out of date by recent constitutional or statutory changes. An error such as appears in the direct quotation on page 167, where nine states are mentioned as granting suffrage rights to aliens who have declared their intention to become citizens, is due to the fact that the quotation is taken from a work published in 1914. But no such obvious reason is apparent for the error on page 57 where it is stated that naturalization can be administered by United States courts only.

The latter part of the book (Part III) is by far the best. Chapter XIV, "American Conceptions of Sovereignty," and Chapter XVII, "Individual Liberty and Authority," are especially stimulating. The extensive bibliography and the thirty-seven pages of Questionnaire and References to Special Readings, add considerably to the value of the book.

J. Tanger.

Patterson, Edwin Wilhite. *The Insurance Commissioner in the United States: A Study in Administrative Law and Practice*. Pp. xviii, 589. Price, $6.00. Cambridge: Harvard University Press, 1927.

This volume is the first of a new series of Harvard Studies in Administrative Law. It is a remarkably able summary and criticism of the forty-eight state departments of insurance based on an exhaustive study of statutory enactments, judicial decisions, departmental rulings and actual practice. The organization, personnel, functions, scope of administrative control, methods of control and amenability to external control of the state departments of insurance are considered in order.

Professor Patterson presents a clear-cut study of one of the most outstanding recent developments in American legal history, namely, the application and enforcement of law through administrative agencies rather than through the ordinary courts.

I. L. POLLOCK.

BEELEY, ARTHUR LAWTON. *The Bail System in Chicago.* Pp. 189. Price, $2.00. Chicago: University of Chicago Press, 1927.

This is a social service monograph recording the results of a pioneer study of the question of bail, with the main idea in mind of discovering a method for predicting the moral risk involved in releasing an accused person without bail pending trial. This investigation will impress the reader as presenting some original and helpful ideas for the improvement of minor and major courts, especially the substitution of the summons for the warrant of summary arrest in all cases where the accused is reasonably sure to appear for trial, and the extension of the Juvenile Court jurisdiction to all persons nineteen years of age or under.

EDWIN O. LEWIS.

FRANKLIN, FABIAN. *The ABC of Prohibition.* Pp. 150. Price, $1.00. New York: Harcourt, Brace and Company, 1927.

This little volume does not purport to be any exhaustive analysis of the prohibition problem, but is merely, as its title suggests, a review of the outstanding features of the question. Mr. Franklin is a philosophical anti-Prohibitionist, and he confines himself almost entirely to a statement of general principles against the Eighteenth Amendment. He admits the inadequacy and ambiguity of statistics, and makes only very slight use of them. He is surprisingly candid and liberal toward the Prohibitionists, although it must be said, I think, that in connection with the reasons for prohibition and the causes of crime he does not say all that might be said for his opponents.

J. H. LEEK.

SEARS, MARTIN. *A History of American Foreign Relations.* Pp. 648. Thomas Y Crowell.

This excellent book of Dr. Sears meets a long-standing need in the literature of American foreign policy. Without attempting to enter into too great detail, the author has given a comprehensive and at the same time philosophic presentation of the development of American foreign policy. One cannot help but admire the self-control shown by Dr. Sears in eliminating the unessential and in confining himself to the basic influences that have determined the foreign policy of the United States.

In many respects, Dr. Sears' book is the most comprehensive text book on American foreign policy that has appeared. It is peculiarly well adapted to purposes of instruction in high schools and colleges and will serve to stimulate the broadening of instruction in this field in our secondary schools and colleges.

CHAPMAN and WESTERFIELD. *Problems in Banking, Money and Credit.* New York: The Ronald Press Company.

This book is designed to meet the vogue of the problem method. The subjects on which problems are presented run the gamut of the field of finance. While very suggestive, many of the problems are undeveloped.

GUEST, HAROLD W. *Public Expenditure.* Pp. xiv, 217. Price, $1.75. New York-London: G. P. Putnam's Sons, 1927.

This book is entitled *Public Expenditure.* The subtitle is "The Present Ills and the Proposed Remedies." One chapter of the book is devoted to the growth of public expenditures, a total of about twenty pages. There is nothing new in the analyses of the figures of this chapter. The remaining two hundred pages are devoted to a rehash of modern social psychology and of some of the classical theories of public finance.

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GREAT BRITAIN'S RECENT TREND TOWARD PROTECTION

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FOREWORD

GREAT BRITAIN has in recent years abandoned the principle of a "tariff for revenue only" as the all-inclusive formula underlying her national fiscal policy. Such a conclusion is supported by the facts which have been assembled in the following study. For many decades ardent believers in free trade, the British have finally succumbed to pressure for modifications along protectionist lines. In a period when world commerce has been expanding to an extent never before experienced, the multiplication of trade barriers presents a serious problem. The application of tariffs menaces and even hinders the continued growth of economic interdependence. This shift in British policy, therefore, is of utmost interest and significance.

It is hoped that the explanation of Great Britain's present tariff position offered in the succeeding pages will assist the reader in understanding her change of system. Such an understanding requires some familiarity with the history of British free trade because the roots of the movement lie in the past. The first chapter, accordingly, contains a brief review of developments prior to the war. The next two chapters trace the trend to the time of writing. Subsequent chapters include an analysis of the various economic forces tending to effect an alteration in the fiscal policy, while the final chapter is given to summary and conclusion.

RALPH A. YOUNG

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Great Britain's Recent Trend Toward Protection

CHAPTER I

Free Trade in Great Britain Prior to 1914

IN January, 1846, came the culmination of long political strife over the tariff issue in the repeal of the Corn Laws. Subsequent years witnessed the vestiges of the old tariff system gradually destroyed. By 1860, the year of Cobden's famous Anglo-French commercial treaty, just forty-eight dutiable articles remained in the tariff schedule and only fifteen of these contributed to revenue.[1] From this date on until 1914, the British tariff schedule was characterized by an absence of duties for other than revenue purposes, The expression, "free trade," became literally descriptive of the British fiscal policy in this era. While free trade was in the ascendancy, tending each decade to become more thoroughly institutionalized, there were, now and again, outbreaks of public opinion from interested quarters demanding an active protectionist tariff policy. From 1900 to 1914, such a movement attained considerable momentum, culminating in the commitment of the Conservative Party to a program of tariff reconstruction, while the Liberal Party remained staunch protagonists of the historic policy of free trade.

The story of the struggle over the fiscal policy during this period holds important source material for such a study as the present one. It is not our task, however, to write a history of the British fiscal-economic policy of tariff for revenue only. We are interested primarily in recent developments. Nevertheless, since some familiarity with the earlier story is indispensable to an understanding of the present trend, it is desirable to point out in review what seem to be the most significant aspects of the pre-war trend. Our review will be a summary rather than a detailed account.

Free Trade and the Flowering of British Industry

Far-reaching reorganization of British industrial life had been the result of the industrial revolution. The new technique of production acquired therefrom provided the capacity for a tremendous expansion of trade. A large foreign market anxious to accept British products in exchange for raw materials and foods stimulated the industrial processes and hastened the full development of the British industrial system. A combination of circumstances, climate, resources, population, creative energy and trading experience enabled Great Britain to utilize effectively the new methods of intensive production. Although population underwent a growth of, roughly, 60 per cent from 1801 to 1851, British export figures, with allowances made for price changes, show an increment of 100 per cent from 1805 to 1840, and about 90 per cent in the next ten years, or a growth of almost 400 per cent for the entire fifty-year period. Real exports of British produce, therefore, were increasing up to 1840 at a slightly greater rate than population, and after that date, at a much greater rate.

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[1] Hirst, F. W., *From Adam Smith to Phillip Snowden* (Unwin, London, 1925), p. 41.

For twenty years after 1850 British trade continued to advance with great strides. A superficial observer might account for this by citing the repeal of the Corn Laws and the inauguration of a free trade fiscal policy, but many other factors contributed, among them, the extensive discovery of gold in this period;[2] the growth of railroad and steamship transportation; the rapid expansion of other human wants, satisfied by machine production, and England's early start in this field; the freedom of British trade from the disturbance of war and the foreign demand for her products stimulated by the American Civil War, Austro-Prussian War and Franco-Prussian War;[3] and finally, the reaction against extreme tariff barriers abroad and the extension of the "most-favored nation" privilege through treaties.[4] Other considerations, too, doubtless contributed to Great Britain's rise to dominant power in the field of foreign trade. This phenomenon, it should be recognized constantly, was the result of an inextricably complex mass of forces.

Succeeding the era of unprecedented prosperity was a period fraught with problems which brought the question of protection once more to the fore. The year 1868 witnessed the most serious industrial and trade depression experienced since the adoption of a free import policy. In this year a "Revivers of Trade Association," organized for the purpose of advocating reciprocity or retaliation against those countries erecting harmful tariff barriers, carried the question before the public.[5] Although the movement died down when trade momentarily revived from 1870 to 1873, interest was resuscitated in the succeeding year. To this flame was added the fuel of sugar bounties on the continent and the denouncement of the Anglo-French commercial treaty by France. Finally, in July, 1861, a new organization, composed of a number of manufacturers drawn together by the continued depression, was called into being under the title, "National Fair Trade League," which advocated a comprehensive change in the fiscal policy.[6]

The new movement quickly aroused interest, and in the depression during the middle of the eighties, assumed large proportions.[7] The fact that most European countries of importance, France, Italy, Germany, Austria and Russia, were in the process of increasing their duties, incited further agitation.[8] Proposals favorable to increased tariffs were advanced in Parliament. Moreover, the Minority Report of the Royal Commission to inquire into the causes of commercial and industrial depression, based its conclusions throughout upon a point of view similar to that of the "fair traders." The movement reached a climax in 1887, when, at a Congress of the Conservative Association held at Oxford, a resolution was passed unanimously in favor of "fair trade." This action forced Lord Salisbury, then Prime Minister, into a position which he had formerly hesitated to assume, because of the necessity of Conservative support. In 1887, however, trade suddenly recovered and the issue disappeared. Although it revived again with the passage of the McKinley

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[2] Mr. Armitage Smith quoted by Drage, G., *The Imperial Organization of Trade* (Smith-Elder, London, 1911), p. 24.

[3] Ashley, Sir William, *The Tariff Problem* (King, London, 1920), p. 54.

[4] *Ibid.*, p. 52.

[5] For an ample treatment of this movement see Fuchs, C. J., *The Trade Policy of Great Britain and Her Colonies Since 1860* (Macmillan, London, 1905), pp. 188–92.

[6] *Ibid.*, pp. 194–6.

[7] *Ibid.*, pp. 196–201.

[8] See also Drage, *op. cit.*, p. 124.

Tariff in the United States, neither party was willing to adopt "fair trade" as part of its platform.

THE ORIGIN AND SPREAD OF COLONIAL PROTECTIVE TARIFFS

Prior to and including the period which has just been traced, Great Britain's attitude toward her colonies had been curiously apathetic.[9] Not since the last of the eighteenth century had more than indifferent attention been directed to their affairs. As a matter of recorded fact, many statesmen manifested a willingness, even a desire, to abandon them altogether as unprofitable.[10] Parliament was neglectful of their welfare, while public interest could be diverted from problems of proximate interest to the remote questions of colonial concern only on extraordinary occasions.[11] It was commonly expected by some that the colonies would sooner or later secede from the Empire.[12] Doubt as to their commercial value was also prevalent, particularly at the cost of eternal coercion and struggle. Self-government grants, consequently, were readily assented to by Parliament; and, save in the case of the Australian Enabling Act of 1850, there were no legal restrictions placed upon the tariff enactments by the self-governing dominions.[13] Evidently, the possibility of colonial tariffs was not considered seriously by British leaders.

It was not long, however, before the growing spirit of independence among the more aggressive colonies resulted in tariff legislation. A tariff act passed by the legislature of the United Provinces of Upper and Lower Canada went into effect in 1858, and was the logical result of her freedom to control her own affairs. A second act was passed in 1859, despite futile protests from interested British business groups,[14] and the free trade propaganda of the Colonial Office. Other colonies were shortly engaged in the process of tariff building. In 1871, after a short struggle with the British Colonial Office and Parliament, the Australian colonies succeeded in establishing tariff laws.[15] In South Africa, a gradual recognition of a community of commercial interests finally bound the various colonies into a customs union (1889), lacking only the coöperation of Transvaal and Natal, the latter joining in 1898.[16] "One after another," writes Mr. E. Porritt of this movement, "their legislatures enacted tariffs with comparatively high protectionist duties, duties that until 1897 were imposed alike on manufactures of British or non-British countries."[17] The confident expectation that free trade would become the established commercial policy of the Empire, which prevailed in Downing Street at the time when the old system was finally destroyed, thus, failed to be realized.[18]

THE EARLY COLONIAL CONFERENCES AND THE MOVEMENT FOR IMPERIAL PREFERENCE

Toward the end of the century, British manufacturers became accustomed to the tariff barriers imposed by the colonies and protests against trade obstacles practically ceased.[19] A new attitude toward the colonies was rapidly developing. More and more, investments in colonial undertakings were absorbed by the London financial market. Emigration to the colonies steadily increased. Educational work by the Royal Colonial Institute and the propaganda of the Imperial Federation League contributed to the awakening of popular interest. Still further attention was attracted to the colonies by the fact of renewed colonial expansion on the part of other European governments, and by the growth of tariff barriers on the continent.

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[9] See Mr. E. Porritt's exhaustive study on this question, *The Fiscal and Diplomatic Freedom of the British Overseas Dominions* (Clarendon Press, Oxford, 1922), Parts V and VI, pp. 283-397.

[10] *Ibid.*, pp. 296–399.

[11] *Ibid.*, pp. 323–99.

[12] *Ibid.*

[13] *Ibid.*, pp. 61–9.

[14] *Ibid.*, pp. 41, 85, 98 and 384–5.

[15] *Ibid.*, p. 100.

[16] Bruwer, A. J., *Protection in South Africa* (Univ. of Penna., Doctoral Dissertation, Philadelphia, 1923), pp. 67–107.

[17] Porritt, *op. cit.*, p. 66.

[18] *Ibid.*, p. 67.

[19] *Ibid.*, pp. 400–1.

Lord Salisbury, the Prime Minister, being sympathetic toward this general interest, and urged by a deputation of the Imperial Federation League, called a meeting of colonial representatives for an interchange of knowledge.[20] Subjects of Imperial defense, and the promotion of commercial and social relations were scheduled to be discussed. Representation was to be quasi-official only. Thus was planned an organization destined to become of great significance as a medium through which Empire interests could be advanced. By means of it was made possible a new sort of Imperial political pressure which was to have an important influence over future British policies. Of the subtle forces tending to shift Great Britain's traditional free trade policy, perhaps there is none more important than the Imperial and Colonial Conferences. At least, we find in them the initial pressure for the Imperial preference movement which has come to play such a heavy rôle in the construction of all Empire tariff schedules.

The 1887 Conference, being purely informal, could pass no resolutions upon subjects discussed. It is a safe observation to make, nevertheless, that, had there been, foremost among them would have been a vigorous one in favor of an Imperial preference tariff system. Enthusiasm waxed strong from the introduction of the subject, even though the Canadian delegates were non-committal and the attitude of the Victorian representatives was tinged with scepticism.[21]

The "seed of ideas which had been sown in 1887" proceeded to germinate in the various colonies. In Canada, particularly, the issue came to a head over the proposal for unrestricted reciprocity with the United States, as against closer union with the Empire.[22] As a result of this struggle, Canada petitioned the Crown requesting the termination of the treaties with Belgium and Germany, which forbade the British colonies from levying higher duties on the imports of those countries than on corresponding imports from Great Britain. It was entreated further, that, in the future, no commercial treaty should be made binding on any colonial government without its express consent. Thus, the attitude of Canada on preference finally was made definite; she required either a position where she could take advantage of her membership in the Empire, or else she desired to go her own way as an independent nation.

In view of this, when, through Canadian efforts, the Colonial Conference of 1894 met at Ottawa, it was natural that discussion should center on the general question of Empire trade, although the ostensible purpose of the Conference was much narrower; *i.e.*, the consideration of trade relations between Canada and Australia and the promotion of the Pacific cable.[23] Out of the discussion came two resolutions, "speedily and unanimously passed," requesting the Imperial Government to take steps to terminate existing treaties which operated to prevent tariff preferences among the colonies; and also to pass legislation enabling the dependencies of the Empire to enter into agreements of commercial reciprocity.[24] Other resolutions affirmed the "practical possibility" and even the "advisability" of an Imperial fiscal system.[25]

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[20] Jebb, R., *Imperial Conferences* (Longmans-Green, London, 1911), Vol. I, pp. 7–9.

[21] Sir Samuel Griffith, Prime Minister of Queensland, introduced the subject and was ardently supported by Mr. Joseph Hofmeyer, of Cape Colony. See either *Ibid.*, pp. 64–77, or *Proceedings of the Colonial Conference, 1887* (C. 5091), pp. 462–3 and 463–8.

[22] Jebb, *op. cit.*, p. 165–6.

[23] *Ibid.*, p. 167.

Mr. Joseph Chamberlain and the Colonial Conferences of 1897 and 1902

Shortly after the events just narrated, Lord Salisbury returned to power, and Mr. Joseph Chamberlain, a prominent Conservative statesman with a pronounced imperialistic bias, chose the portfolio of the Colonial Secretary as his part in the new Government, even though this office had been deemed of secondary importance hitherto. Mr. Chamberlain had taken considerable interest in colonial development, and believed that the British Government should take every advantage to bind the colonies to the Crown, even with the view of ultimate federation.[26] The establishment of commercial union he considered to be the first step. Consequently, little surprise was evinced when he threw open the Conference of 1897 to an unreserved discussion of the question of Imperial trade relations. Nor, further, when he advised the Conference that, if it thought wise, the Crown would consider the termination of the Belgian and German treaties.[27] Resolutions passed by the visiting Premiers agreed to consider with their governments the problem of preference, and requested the British Government to terminate the above-mentioned treaties.[28]

The response of the Crown to their wishes with respect to the treaties was immediate, for it was shortly made public that they had been officially abrogated.[29] It was stated further that, after July 30, 1898, nothing would remain in any of Great Britain's treaties to stand in the way of preference grants on the part of the colonies in favor of United Kingdom produce. With this announcement was also a warning regarding the possible extension of the "most-favored nation" clause in the event of preference grants to foreign nations. The Colonial Premiers were thus able to return to their respective legislatures with a distinct concession from the mother country. The Colonial Secretary, while wholly sympathetic, made it clear, however, that, whether or not there could ever exist sufficient political demand for preference in Great Britain, must depend largely on the colonies and the effective demands of their citizens.

It is doubtless true that there was little enthusiasm of a popular nature in many colonies. In Canada, where preference had been granted just before the Conference, there may have been more than elsewhere. In South Africa and Australasia other issues were paramount. The insignificance of preference as a popular political issue is confirmed by the fact that no further preferences were adopted by any colony in compliance with the second resolution. Nor were any even seriously proposed. Meanwhile, the British Government itself was shortly engaged in the colonial war in South Africa.

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[24] Jebb, *op. cit.*, pp. 167–71.

[25] *Ibid.*, pp. 172–88. It is interesting to note, in this connection that Lord Jersey, the British representative, although not a supporter of the Liberal Government which sent him, stated in his report to the Colonial Office that sentiment alone could never hold together the British Empire, and suggested that the solution lay in Britain's power to change the course of trade in such a way as to bind the colonies to her. Lord Rippon, the Colonial Secretary, cautiously and firmly replied to this report and to the Conference resolutions with a careful exposition of the principles of free trade, and with a statement that the Government could not terminate its treaties with Belgium and Germany. Full fiscal liberty, however, was granted by the Crown to the Australasian colonies (Canada and South Africa already possessing it). *Ibid.*, pp. 231–7.

[26] *Ibid.*, pp. 303–11.

[27] *Proceedings of the Colonial Conference, 1897* (C. 8596), pp. 10–11.

[28] *Ibid.*, pp. 14–5.

[29] *Ibid.*, p. 15.

New developments appeared in the 1902 Conference. Opened as it was by Mr. Chamberlain with a strong Imperial appeal, and the declaration that the demand for closer union could not originate with the mother country, the Conference delegates came forward with some definite offers for the preferential treatment of British goods.[30] In addition, the principle of reciprocal preference was affirmed in a group of strong resolutions, and the premiers were requested to take up necessary measures with their respective Governments.[31] Finally, Canadian delegates presented a further memorandum to the Conference requesting the United Kingdom to reciprocate her preference grants by tariff exemptions on Canadian food, for which privilege she was ready to extend her existing preference allowance.[32] Moreover, the memorandum warned that if the Imperial Government rejected the principle, and if the principle were not acceptable to the other Colonial Governments, Canada would be forced to act as her interests dictated.

THE REVIVAL OF FISCAL CONTROVERSY AND THE CHAMBERLAIN CAMPAIGN

At that time, there existed in the British Budget certain duties on foreign corn and flour which had been established to raise revenue for the South African War. The Canadian Ministers had chosen a strategic moment to place their memorandum before the Imperial Government. Certainly the issue was clearly defined, whatever the value of the preferences offered. Such demands by the colonies were exactly what Mr. Chamberlain had announced to be the conditions necessary for his Government to consider seriously fiscal reform. When the British Government failed to take up the matter and the corn duties were repealed by the Budget in the following spring, colonial leaders probably were offended by what appeared to be "a slap in the face" from the professedly imperialistic party in Britain.[33] Mr. Chamberlain, while forced to drop his proposals temporarily, on May 15, 1903, brought the matter to the attention of his Birmingham constituents, reopening by this act, the "floodgates of controversy."[34]

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[30] See Mr. Chamberlain's opening address to the Conference. *Proceedings of the Colonial Conference, 1902* (Cd. 1299), pp. 5–7, or Jebb, *op. cit.*, pp. 352–7; and the preference offers of various colonies, *Conference Proceedings*, pp. 35–6, or Jebb, pp. 366–7. These latter are as follows:

Canada.—The existing preference of 33⅓%, and an additional preference on lists of selected articles; (a) by further reducing the duties in favor of the United Kingdom; (b) by raising the duties against foreign imports; (c) by imposing duties on certain foreign imports now on the free list.

Australia.—Preferential treatment not yet defined as to nature and extent.

New Zealand.—A general preference by a 10% allaround reduction of the present duty on British manufactured goods, or an equivalent in respect of lists of selected articles on the lines proposed by Canada.

The Cape Colony and Natal.—A preference of 25% or its equivalent on dutiable goods other than specially rated articles, to be given by increasing the duties on foreign imports.

[31] *Conference Proceedings, op. cit.*, p. 36.

[32] *Ibid.*, p. 36–8.

[33] Jebb, *op. cit.*, Vol. II, p. 45.

[34] In this connection, see Hewins, W. A. S., *Trade in the Balance* (Allan, London, 1924). Prof. Hewins was intimately associated with Mr. Chamberlain in this campaign as head of his Tariff Commission. He continues to be an advocate of tariff protection.

When the question came before the House of Commons, Mr. Balfour, the Prime Minister, declined to support unequivocally Mr. Chamberlain's proposals. He took a middle stand, however, acknowledging that the country was no longer in the position occupied by it when free trade was adopted, and admitting that a tariff might be useful for purposes of retaliation and bargaining. There was, perhaps, good basis for this position. Upon the continent had grown up a series of commercial treaties among protective countries, from which Great Britain had been excluded and which were due to expire about 1904 to 1906. The threat of a tariff might have regained a more favorable position for Great Britain among her rivals.

Rather than embarrass Mr. Balfour, under the circumstances, Mr. Chamberlain resigned from the Cabinet and gave himself to propagandizing for his cause.[35] Five other Ministers of free trade bias also resigned and the campaign began in earnest. The Tariff Reform League was organized at Birmingham, while the Tariff Commission originated by Mr. Chamberlain proceeded to draw up a "scientific" tariff. Mr. Chamberlain traveled over the country preaching the advantages of fiscal reform to local industries, and planning to force an election on the issue.[36] Mr. Balfour, however, managed to maintain such an even balance in his fiscal views that "each section of his party could interpret them in its own favor."[37] The election was delayed and the campaign went on, with the Free Trade Union and the Cobden Club carrying on an extensive counter-propaganda.

The difficulties facing the Balfour Government during these years must have been very great. Chamberlain's efforts were splitting the party. Save for the fact that a party division at this time would have allowed the Liberals to come into power with their program of Irish Home Rule, there was little to hold the Unionist party together. A crisis finally came and Mr. Balfour tendered the resignation of his Ministry. In the general election which followed, free trade was the dominant issue. The Unionists met with overwhelming defeat, and the Liberal party came into power with Sir Henry Campbell-Bannerman at its head.

Although decisively defeated, tariff reform did not relinquish its place in the political arena. The Tariff Reform League continued its activities, as did likewise Mr. Chamberlain's Tariff Commission. Fuel was added to the controversy by the publication of a free trade memorandum on "The Fiscal Policy of International Trade," prepared by the late Professor Alfred Marshall, the eminent economist, as a Parliamentary Paper.[38]

Mr. Chamberlain, though forced by ill-health to retire from active participation, retained a lively interest in the problem. Mr. Balfour, finally converted to the former's ideas on fiscal reform, in 1909 declared himself a firm believer.[39] His new program advocated a duty on wheat, although he pledged that none would be levied on cotton and rubber. He argued further that tariff reform was essential to secure the home market from unfair competition. The general election of 1909, which the Conservatives forced on the issue of Mr. Lloyd George's Budget, failed, however, to reseat them.

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[35] For a short, vivid description of the campaign see Hirst, *op. cit.*, pp. 49–56.

[36] Hewins, *op. cit.*, p. 17. Mr. Hewins states that in October, 1903, some eminent opponents informed him that Chamberlain could carry the nation.

[37] Hirst, *op. cit.*, p. 54.

[38] While denying the need for tariff reform, Marshall did advocate the use of any and all financial weapons in reprisal against the refusal of the "most-favored nation" privilege to British trade. Parliamentary Papers, 1908, 321.

[39] Drage, *op. cit.*, pp. 155–6.

Shortly after the election, opposition developed to the leadership of Mr. Balfour, and, in November, 1911, he was supplanted by Mr. Bonar Law. The Unionist party now gave themselves to a complete scheme of protection and Imperial preference. Mr. Austen Chamberlain reported that the Conservative party proposed to put a 5 per cent duty on foreign foodstuffs and an average of 10 per cent on foreign manufactures. At the party meeting in November, 1912, a movement successfully took place to remove the referendum pledge of Mr. Balfour, which had promised to refer the principles of the tariff to a popular vote.[40] At the same meeting, Mr. Bonar Law declared that tariff reform was the party's most constructive plank, although food duties were involved. Later opposition which developed within the party forced the postponement of the proposal of food taxes.

This is the situation in which we find tariff reform just prior to the period of the War. The Conservative Party had committed itself irrevocably to tariff reconstruction, that is, as irrevocably as a political party can. Public interest in the question waned just before 1914 and was overshadowed by the problem of Ireland. As for industry and trade, since 1905, imports and exports had shown a lively upward trend. Dark forecasts about the retrogression and decline of Great Britain's trade no longer were capable of arousing great interest. Fiscal reform was in the background and destined to remain there until the exigency of a new and complex emergency should force it out.

THE IMPERIAL CONFERENCES OF 1907 AND 1911

We are not ready to pass on to the developments of the War period until we have paused to consider the incidents of the two Imperial Conferences, as they came to be called, which took place in 1907 and 1911. The first, scheduled for 1906, was not held until the following year in order to allow the new Colonial Secretary, Lord Elgin, time for preparation. According to past custom, members were invited to submit subjects for discussion. The inevitable transpired; questions of preference and Imperial organization were among the most common ones presented.[41] It almost appeared that the Conference would "redound to the advantage of the opposition party, owing to the evident prominence of preference."[42] Its treatment in the Conference was characterized largely by debate, with the Liberal Ministers on the defensive before the British public with its divided sentiment. They were candid about having pledged themselves against "countenancing the smallest departure, no matter how trivial in itself, from the principles of the existing fiscal system."[43] Any concession to the Conference would have invalidated their platform and discredited them before the country.

Nevertheless, there were some significant offers made by Colonial Ministers. Although the proposal for an intercolonial "most-favored nation" arrangement, introduced by Mr. Deakin, the Australian Premier, was quietly quashed, definite offers of additional preference for reciprocation on Great Britain's part were made by Australia, New Zealand and South Africa, while

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[40] Hirst, *op. cit.*, pp. 58–9.

[41] Jebb, *op. cit.*, Vol. II, pp. 27–32.

[42] *Ibid.*, pp. 64–5.

[43] *Ibid.*, pp. 181–7.

Newfoundland and Transvaal representatives agreed to subscribe to the 1902 resolutions.[44] Only the Indian representative opposed the idea.[45] The discussion ended by the passage of resolutions, of which the first, proposed by the Liberal Ministers, was simply a reaffirmation of the old principle of fiscal freedom, well-couched in diplomatic language, acknowledging the justice of permitting the special requirements and conditions of each member of the Empire to govern its contributions to Imperial commercial relations.[46] Two other motions, one of general nature and the other a strong reaffirmation of the 1902 resolutions were passed, the British ministers, of course, dissenting from the latter.[47]

In the 1911 Conference two steps were taken which may be regarded as victories for the Colonial delegates. The first was the acceptance by the Conference of a Canadian proposal that His Majesty's Government should open negotiations with several foreign governments in order to secure liberty for any of those who might choose to withdraw from the operation of certain commercial treaties.[48] No invalidation of the treaty regarding the rest of the Empire was desired. What was sought was such release from outside obligations as would enable the extension of intra-Empire preference arrangements, and also the privilege of the dominions to erect higher protective duties against whomever they desired. The Crown's acquiescence was merely a diplomatic step, for its acceptance contained the condition that new treaties could be negotiated to replace existing ones, a condition which required the accession of the other parties, and was impossible of attainment.

The second resolution, passed unanimously, was by far the more significant.[49] It proposed a Royal Commission representing all sections of the Empire to investigate and report upon the natural resources of each part of the Empire, the facilities for production and trade, and the effect of existing commercial legislation. On the whole, such a resolution could cause the Liberal Government no embarrassment. Yet it may be considered a colonial victory because it committed the Liberal Ministers to a more decided Imperial policy than they had been willing to assume heretofore.

It is plainly very difficult to interpret the influence these Conferences may have had upon the Liberal Home Government. The 1907 Conference was its initial contact with that sort of political pressure. It is not unreasonable to suppose that an ineffaceable impression was made by a realization of the vast resources and population represented at the Conference table.[50] This impression may have prepared the way for its war-time protectionist compromise. Whatever the possibilities on that score may be, one thing only was certain, the Crown's position for the time on the question of trade relations with the colonies was clearly defined. It succeeded in checking effectively, though only temporarily, further advances toward preferential protection.

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[44] Jebb, *op. cit.*, Vol. II, pp. 187–218.

[45] He was a delegate from the Indian Office, rather than India, and a Liberal supporter, *ibid.*, pp. 219–22.

[46] *Proceedings of the Imperial Conference, 1907* (Cd. 3523), pp. 429–38.

[47] *Ibid.*, pp. 439–40 and 429.

[48] *Proceedings of the Imperial Conference, 1911* (Cd. 5745), pp. 333–9.

[49] Likewise a Canadian suggestion offered as a compromise to a stronger Australian resolution reaffirming the 1902 preference resolutions, to which, of course, the Home Government could not assent. *Ibid.*, pp. 339–44.

[50] It is significant to note here that Mr. Richard Jebb, the authority on Imperial Conferences, observes a certain sympathy in Mr. Lloyd George's speeches to the preference idea and Imperial movement. Party obligations, asserts Mr. Jebb, prevented him from being more generous in his attitude. Mr. Jebb wrote in 1911. See his work, Vol. II, pp. 233–40.

THE EXTENT OF PREFERENCE GRANTS BY THE SELF-GOVERNING DOMINIONS, 1900 TO 1914

It is illuminating to note briefly, before leaving this period, the extent to which tariff preferences on British manufactures had come to be granted by the various colonies. Canada, for instance, had followed up her original preference grant of 1897 with an additional grant in 1900, extending to one third of the existing duties. Complaints from Canadian manufacturers brought a reduction in this preference in 1904.[51] In 1907, uniform percentage preference was abandoned, and specified preference rates were substituted showing variously a greater or less reduction than one third on British goods. In addition, an intermediate tariff for purposes of negotiation was adopted.

Following Canada's example in this respect, New Zealand, in 1903, added a surtax to certain imports, some thirty-eight items, from foreign countries.[52] This number was increased to one hundred and ninety-four in 1907. Under a reciprocity clause in the 1903 Act, she entered into a preferential arrangement with South Africa in 1906, but reached no other agreements either with foreign countries or other colonies.[53] In Australia, however, a preferential tariff did not make its appearance until 1908, although she entered into a reciprocal arrangement with South Africa two years before.[54] The basis of her tariff preference was, as with New Zealand, protection of her own industries first. Consequently, preferences were created by increasing the duties on imports from other countries. Notwithstanding this, it was reported by the Dominions Royal Commission that throughout Australasia there existed a marked enthusiasm for the principle.[55]

South Africa, with her Customs Union and her tradition of protection might have been expected to enact a preference tariff at an early date. It was not accomplished, however, without overcoming some opposition, especially that of Cape Colony.[56] Only through the efforts of Lord Milner, His Majesty's High Commissioner in South Africa, and those of Mr. Chamberlain, was the preference promised at the 1902 Conference, enacted the following year.

The preferences granted by the colonies were unquestionably not large. Most of them were obtained by increasing the duties on foreign produce, colonial industry being amply protected against British products, though some British goods profited by them. Concerning the extent of their influence on Empire trade, there exists no barometer for measurement.[57] As to their effect upon the British fiscal policy, conclusions will be suggested later as the reader acquaints himself with further developments. Unquestionably, some pressure from colonial sources was being felt in Downing Street.

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[51] Culbertson, W. S., *International Economic Policies* (Appleton, N. Y., 1925), pp. 161–2.

[52] *Ibid.*, pp. 170–1.

[53] *Ibid.*, p. 176.

[54] *Ibid.*, pp. 165–6.

[55] Dominions Royal Commission, *Second Interim Report*, 1914 (Cd. 7210), p. 7.

[56] Bruwer, *op. cit.*, p. 122. The Premier of Cape Colony, however, favored preference at the Colonial Conference of 1902.

[57] The amounts of duty remittances or reductions by the various dominions for the few years prior to the War are suggestive. For example, they were, for Australia, in 1910, in thousand pounds sterling, 972; Canada, 1303; New Zealand, 536; South Africa, 594; and in 1913, for Australia, 1244; Canada, 1573; New Zealand, 760; and South Africa, 628. See in this connection the Dominions Royal Commission, *Second Interim Report*, 1914 (Cd. 7210), p. 7; *Fifth Interim Report*, 1917 (Cd. 8457), p. 7; *Third Interim Report*, 1914 (Cd. 7505), p. 7.

Our procedure up to this point has been to acquaint the reader, as briefly as possible and yet as exhaustively as space has permitted, with the immediate background of the British tariff problem, to the end that a more searching survey of the recent trend toward protection may be made. The following chapter will treat the protectionist developments during the War, and the succeeding one will carry the study up to the present time. Subsequent chapters deal statistically with an analysis of British economic trends and their significance in explaining the late protectionist movement.

CHAPTER II

THE WORLD WAR AND PROTECTION IN GREAT BRITAIN

FOLLOWING the outbreak of the World War, the Asquith Liberal Government early faced difficulties with its program. Having failed to achieve any conspicuous military success, the Government found that political expediency made it necessary to take several Conservative leaders into the Cabinet. The object, it was averred, was to effect a national unity and unanimity, essential to a successful termination of the War. Domestic controversies, in the meanwhile, were to be placed, as Mr. F. W. Hirst states, "in cold storage." With a substantial majority in the House of Commons, and a War of unprecedented proportions going on, it did appear that the issue of protection and preference would be obscured.

Several circumstances operated to vitiate this possibility. In the first place, British industry was finding itself tremendously handicapped by the lack of certain essential products whose production was controlled by enemy interests. The military handicap of being so thoroughly a dependent industrial nation was forcefully brought to the attention of statesmen, officials and business men. In the second place, there was an inevitable and universal realization of certain reputed economic designs of Germany which were said to be a part of her general war policy. Coupled with this was a growing fear that Germany was preparing to sweep down and destroy all Britain's industry and trade. Then there were the colonies which so patriotically had stood by the mother country in her emergency, placing the latter, however, in a position of very real obligation. Finally, certain problems of expediency arose necessitating fiscal action for temporary alleviation.

THE MCKENNA DUTIES OF 1915

The first of the circumstances to be treated here belongs in the last of the above-named categories. In September, 1915, Mr. Reginald McKenna, the Chancellor of the Exchequer, proposed a startling innovation. His Budget contained a 33⅓ per cent duty upon a series of articles, including motor cars, motor cycles and parts thereof, cinema films, clocks, watches, musical instruments, plate glass and hats. He urged in his proposals that goods of such a nature should be taxed from the very outset in order to provide revenue and to cut consumption which was deemed unnecessary. He denied that it was a question of tariff reform or of protection.[1] His purpose, which so frequently has been misinterpreted, is best set forth in his own words:[2]

> We have to tax now with objects beyond revenue, with objects which are purely temporary, and without regard to the permanent effect upon trade. We must look at the state of our foreign exchange. We must discourage imports. Some of us think that, in ordinary circumstances, imports if excessive will necessarily be discouraged and exports will necessarily increase. But this is not true today. We cannot increase our exports because our capital and labor are otherwise engaged. We have then to look upon the reduction of imports as an object in itself. Then we also have to have strict regard to the necessity of reducing consumption. If, thus, we can by any means of taxation, at one and the same time, reduce imports, and reduce consumption, and bring in revenue, then I think, for the moment at any rate, we may consider to have found an ideal system.

It was also contended in defense of these duties that shipping space would be saved, although this argument could not be advanced for all articles.[3] Of course, the preference proponents were not missing, but such proposals as they made were rejected.[4] As for the length of time that the duties would remain a part of the fiscal system, it was practically promised by Mr. McKenna that they were strictly a war measure and would be discontinued with the passing of the emergency.[5]

THE PARIS RESOLUTIONS OF 1916

Concurrently with the adoption of the McKenna duties, in fact since the outbreak of the War, certain suspicions and fears regarding Germany's economic motives had been growing. Business men in general were filled with grave misgivings, and continually disturbed by dreadful apparitions concerning post-war trade. A Sub-Committee of the Advisory Committee to the Board of Trade, conducting an investigation into the condition of a group of minor industries about this time, came to the conclusion that the question of protection was the most important they had to consider. "Practically all the representative firms and associations consulted by us," stated the Report, "asked for a measure of protection."[6] There was a widespread fear, the Committee further noted, that the country would be flooded with German and Austro-Hungarian goods after the War, "sold at any price they would bring with a view to capturing trade hitherto carried on by enemy countries." Business men testified to the Committee that German industries were producing and accumulating stocks preparatory for this purpose.[7]

The Sub-Committee concerned itself with other phases of protection, and in its report urged several recommendations of a revealing nature. If we may interpret them as a rather substantial representation of British business and industrial opinion at that time, some light is shed upon subsequent developments. A portion of the report is well worth quoting in this connection:[8]

> We are of the opinion that, when the national supplies of certain manufactured ar-

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[1] *Parliamentary Debates*, Commons, Vol. LXXIV, 1915, Col. 1724–5.

[2] *Ibid.*, Col. 351–2.

[3] Hirst, *op. cit.*, p. 63. Mr. Hirst emphasizes this idea of shipping space economy as an argument for the McKenna duties, though the writer was unable to find any emphasis upon it in the House Debates.

[4] *Parliamentary Debates*, *op. cit.*, Col. 1749–62.

[5] *Ibid.*, Col. 1724–5.

[6] Committee's *Report*, 1916 (Cd. 8275), p. 11. Of course, some of these industries are those which suffered most from pre-war competition.

[7] *Ibid.*, p. 11.

[8] *Ibid.*, p. 16.

ticles, which are of vital importance to the national safety or are essential to other industries, have fallen into the hands of manufacturers and traders outside this country, British manufacturers ready to undertake the manufacture of such articles in this country should be afforded sufficient tariff protection to enable them to maintain such production after the War.

With reference to the strongly expressed opinion of many of the witnesses that the enactment of protective duties on the industries other than those referred to in the preceding paragraph, which have formed the subject of our inquiry, is essential to their maintenance, we wish to report that in view of the following considerations:

(a) That there exists a strong desire to respond to the feelings of our Dominions in favor of an Imperial Preference in trade, and that there is also a strong desire to arrange preferential trading with those who are our Allies in the present War, and

(b) That the present high direct taxation tends to raise the rate of interest on money, and cheap abundant capital for the employment of their labor is of the greatest importance to the working classes,

It will be necessary to impose some widely spread import duties, and we are therefore prepared to recommend that a larger proportion of the revenue be raised by import duties.

We are of the opinion that such import duties would go a long way towards satisfying the requests for special protective treatment for the industries which we have under consideration.

It was in the sentiment revealed by this Report that the famous Paris Resolutions originated.[9] The same month in which it was published, January, 1916, a motion was made and passed unanimously in the House of Commons, which called upon the Government "to enter into immediate consultation with the Governments of the Dominions, in order, with their aid, to bring the whole economic strength of the Empire into coöperation with our Allies in a policy directed against the enemy."[10] The Paris Economic Conference followed in June, and passed a series of resolutions, framed in advance by Mr. Walter Runciman, President of the Board of Trade, with the approval of Mr. Herbert Asquith, the Prime Minister; Mr. Walter Long, the Colonial Secretary; and two representatives of the Dominions, Mr. W. M. Hughes, and Sir George Foster. The resolutions included recommendations for Allied economic measures during the period of the War; during the period of reconstruction; and lastly, permanent measures. In them, among other things the Allies agreed to take all necessary steps to make themselves independent of the enemy countries, so far as raw materials and manufactured products, as well as financial, commercial and maritime organization were concerned.[11] Accordingly, almost any methods could be applied in carrying out the agreement, as the subsidizing, direction or control of enterprises by governments; financial assistance for the encouragement of scientific and technical research, and the development of national industries; the application of customs duties or prohibitions of a temporary or permanent character, or a combination of them all. Whatever the method, the object desired was such increased production within Allied territories as to enable them to develop and maintain their economic position independently of enemy countries.

Referring to these resolutions shortly after, Mr. Asquith announced in the House of Commons that they had been adopted as part of the Government's policy, which he hoped met with the approval of Parliament.[12] In defending this action, he gave classic expression to the general trepidation current at the time. He declared:[13]

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[9] Hewins, *op. cit.*, pp. 37–40.

[10] *Ibid.*, p. 38.

[11] Paris Economic Conference, *Resolutions*, 1916 (Cd. 8271).

[12] *Parliamentary Debates*, Commons. Vol. LXXXV, 1916, Col. 340–1.

> The War has opened our eyes to the full meaning and manifold implications of the German system of economic penetration, and commercial and financial control of vitally important industries and to the use to which vantage ground gained by this system can be put in war. It is difficult—indeed, I think it is impossible—to believe that Germany would not be animated by the same spirit and policy when the War is over, and that she will start, be it observed, with certain very considerable advantages. They are already organizing their industry—and do not let us be blind to this—for an attack on our Allied markets and for a vigorous and, if possible, victorious competition in neutral markets. It is then in our view—when I say our view I mean the view of the Allied Powers—necessary to make thorough preparations for the coming peace, and the Paris Economic Conference and the Resolutions passed there represent the attempt of the Allies to decide the general lines on which that preparation should proceed.

Adoption of the resolutions as part of the Government's policy was not without opposition, because Mr. Asquith had pledged that the British delegates would return from the Paris Conference uncommitted.[14] The Government announced, however, that no action would be taken immediately, but that a Committee had been appointed under the Chairmanship of the late Lord Balfour of Burleigh, to investigate and present definite means of carrying out the suggestions of the resolutions.[15] Thus, the question of Parliamentary approval was postponed until the report from this Committee was received, and definite proposals were ready to be made.

THE LORD BALFOUR OF BURLEIGH COMMITTEE

The Committee, known as the Committee on Industrial and Commercial Policy after the War, was composed of both Conservative and Liberal members. It began its work at once and shortly issued an interim report, which appeared just before the meeting of the Imperial War Conference, a Conference consisting of all the Colonial Premiers. The Committee felt, as they stated in an accompanying letter to the Prime Minister, that, though acts in restraint of trade are distasteful in the abstract, Imperial interests made a serious attempt to meet the declared wishes of the dominions and the colonies very desirable.[16] The sacrifices made and the services rendered, it was further stated, made the time particularly appropriate for the declaration of such a policy. Then, too, the Committee felt that the recovery of trade lost during the War, the securing of new markets, and the consolidation of Empire resources could best be facilitated throughout the Empire, by a system of mutual protection. Consequently, the Committee presented the following resolutions:[17]

> 1. In the light of the experience gained during the War, we consider that special steps must be taken to stimulate the production of food-stuffs, raw materials and manufactured articles within the Empire wherever the expansion of production is possible and economically desirable for the safety and welfare of the Empire as a whole.
>
> 2. We therefore recommend that His Majesty's Government *should now declare their adherence to the principle that preference should be accorded to the products and manufactures of the British overseas Dominions, in respect of any Customs Duties now or hereafter to be imposed on imports into the United Kingdom.*

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[13] *Parliamentary Debates,* Commons. Vol. LXXXV, 1916 Col. 333.

[14] *Ibid.,* Col. 380–2.

[15] *Ibid.,* Col. 339.

[16] *Interim Report,* 1917. (Cd. 8482), p. 1.

[17] *Ibid.,* p. 3. (Italics are the writer's).

3. Further, it will, in our opinion, be necessary to take into consideration, as one of the methods of achieving the above objects, *the desirability of establishing a wider range of Customs Duties which would be remitted or reduced on the products and manufactures of the Empire and which would form the basis of commercial treaties with Allied and Neutral Countries.*

THE RESOLUTIONS OF THE IMPERIAL WAR CONFERENCE, 1917

The Imperial War Conference, which had been called for the purpose of securing closer co-operation within the Empire in pushing the War, met early in the spring of 1917. After due deliberations, of which but smatterings are published, a resolution was passed by the Conference favoring the establishment of an Imperial preference system. Since the resolution had previously met with the unanimous approval of the Imperial War Cabinet, consisting only of Imperial Prime Ministers, its adoption in reality was mere reaffirmation.[18] It represented, as passed, not only an expression of opinion by the Colonial representatives, as had former resolutions of Imperial Conferences, but also the expression of an opinion by the British Government. Thus, Great Britain tied herself definitely to a policy of Imperial preference.

This resolution which Mr. Hewins describes as the "key" resolution to future developments of policy, declared in definite terms that "the time has arrived when all possible encouragement should be given to the development of Imperial resources, and especially to making the Empire independent in respect to food supplies, raw materials, and essential industries." [19] The resolution contained a clause, moreover, which expressed unequivocal approval of the principle that each part of the Empire should give especially favorable treatment and facilities to the produce and manufactures of other parts of the Empire, with due regard, of course, for the interests of the Allies. In addition, arrangements should be made to induce British emigrants to settle within the Empire. Concerted Imperial action, finally, was deemed necessary to arrange in the future for an adequate food supply and its transportation, and also for the control and economical utilization of resources essential for national purposes.

Since this action was concurred in by the British Government, the next step was the working out of a practical preference plan. Mr. Long, the Colonial Secretary, announced in the House of Commons, a Cabinet Committee to inquire and report on the methods required to render the resolution effective.[20] This Committee, called the Committee on the Trade Relations of the United Kingdom within the Empire, considered a group of subjects such as: (1) preference both by means of tariff and administrative measures, (2) the position of commercial treaties in view of conditions arising out of the War; (3) the resources of the British Empire.[21]

THE LORD BALFOUR OF BURLEIGH COMMITTEE, FINAL REPORT

In the meantime, the final report of the Balfour of Burleigh Committee was received, recommending a comprehensive change in the fiscal policy. These recommendations are the culmination of the war movement toward tariff protection. Their inclusion here is, therefore, pertinent:[22]

(1) The producers of this country are

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[18] Hewins, *op. cit.*, pp. 41–2.

[19] *Proceedings of the Imperial War Conference, 1917* (Cd. 8566), pp. 114–5.

[20] *Parliamentary Debates*, Commons, Vol. XCVII, 1917, Col. 1003.

[21] Hewins, *op. cit.*, pp. 43–4.

[22] Committee on Commercial and Industrial Policy after the War, *Final Report*, 1918 (Cd. 9035), p. 52.

entitled to require from the Government that they should be protected in their home market against "dumping" . . . , and against the introduction of "sweated goods." . . . We agree that it will often be difficult to distinguish between "dumping" and between cheap production and "sweating," but it will be the duty of our trade representatives in foreign countries to investigate and report on these matters, and reliance must be placed upon the manufacturers in this country, so that the operations of the customs officials may be intelligently directed to stop these unfair forms of trade.

(2) Those industries which we have described as "key" or "pivotal" should be maintained in the country at all hazards, and at any expense. No ordinary economic rules apply to the situation of these minor but important industries. They must be kept alive, either by loans, by subsidies, by tariffs, or Government contracts, or in the last event, by Government manufacture. They will necessarily be subject to Government supervision.

(3) As regards other industries, protection by means of customs duties or Government assistance in other forms should be afforded only to carefully selected branches of production which must be maintained either for reason of national safety, or on the general ground that it is undesirable that any industry of any importance to our economic strength and well-being, should be allowed to be weakened by foreign competition, or brought to any serious extent, in this or other ways, under alien domination or control.

(4) Preferential treatment should be accorded to the British Overseas Dominions and Possessions, in respect of any Customs Duties now, or hereafter, to be imposed in the United Kingdom, and consideration should be given to the expediency of other forms of Imperial Preference.

(5) As regards our commercial relations with our present Allies and with Neutrals, the denunciation of existing commercial treaties for the purpose of affording special treatment to such of our Allies or of the Neutrals as might be disposed to make reciprocal concessions, is unnecessary and unexpedient. But the present opportunity should be taken to endeavor to promote our trade with the Allies, and consideration should be given to the possibility of utilizing for purposes of negotiation with them and present Neutrals, any duties which may be imposed in accordance with the principles which we have laid down before.

In addition to these recommendations, a Special Industries Board was proposed, to work with the Board of Trade, in determining essential industries which should otherwise be maintained on general grounds of safety or economic desirability.[23] Some assistance to such industries ought to be extended, it was felt, but it was admittedly difficult to determine just what industries should be included. The Committee suggested that the list might possibly include, indeed, appeared to them to include, the heavy iron and steel industries, the numerous branches of manufactured iron and steel goods; the engineering trades, including electrical and motor engineering; the production of a considerable number of non-ferrous and ferro-alloys; ship-building; many branches of the chemical trades; the textile trades, almost as a whole; the manufacture of various classes of rubber goods, especially tires; and the leather industries.[24] Nearly every important British industry is included in one of these categories; and hence, falls within the scope of this recommendation, according to the Committee itself.

As a matter of fact, most of the industries in question did feel that they should be the recipients of protection under this head. The accompanying table, Table I, which will merit the reader's careful attention, summarizing the recommendations of various Departmental Committees appointed by the Board of Trade to consider the position of some of these industries fol-

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[23] Committee on Commercial and Industrial Policy after the War, *Final Report*, 1918 (Cd. 9035), p. 52.

[24] *Ibid.*, p. 44.

TABLE I—GIVING SUMMARIES OF THE STATEMENTS AND RECOMMENDATIONS WITH REGARD TO PROTECTIVE TARIFFS FOUND IN THE REPORTS OF THE VARIOUS DEPARTMENTAL COMMITTEES APPOINTED BY THE BOARD OF TRADE TO CONSIDER THE POSITION OF CERTAIN INDUSTRIES AFTER THE WAR

Industry	The Position of the Industry on Protective Tariffs as Evidenced by the Reports	Amount and Type of Tariff Suggested
Electrical Trades[1]	Many witnesses expressed the view that protection would be necessary after the War	Duties should be sufficiently high to afford ample protection. Measures should be enacted against dumping
Engineering Trades[2]	Majority of Committee believed tariff would be necessary	No definite suggestions, save with regard to preference which ought to be large enough to induce reciprocal treatment
Iron and Steel Industries[3]	Committee believed that safeguarding would be necessary. Feeling unanimous in industry for this sort of protection. Also a general protest against dumping	Amount should be large enough to safeguard and protect industry. Preferences large enough to induce reciprocity should be given. Dumping should be prevented
Shipping and Ship-building Trades[4]	Committee reported industry as opposing duties on any article used by them, urging need of freedom in making purchases. Sentiment in favor of anti-dumping legislation	
The Textile Trades: (a) The Cotton Industry[5]	Little demand in this industry for any change in the present policy. Fear increase of production costs if duties imposed	
(b) The Woolen Industry[5]	Differences of opinion among producers of woolen and worsted goods for men. Dress goods producers favor protection	Dress goods producers desire a small tariff on yarns and a higher one on dress goods
(c) The Carpet Industry[5]	Large majority of producers in this industry seem to favor protection	A tariff as high as 20 per cent suggested, with preference for the Dominions and Allies
(d) The Silk Industry[5]	Practically a unanimous request for a tariff. Said to be an "infant" industry	Varying duties suggested from 12 per cent to 40 per cent with Empire goods free
(e) The Jute Industry[5]	In favor of protection, especially a type of export duties profitable to itself	An export duty on jute leaving India with a refund in favor of Empire destinations

TABLE I—*Continued*

Industry	The Position of the Industry on Protective Tariffs as Evidenced by the Reports	Amount and Type of Tariff Suggested
(f) The Linen Industry [5]	A general feeling in favor of protective duties	No suggestion save that distinction be made between Allied and enemy countries
(g) The Hosiery and Fabric Glove Industry [5]	A practically unanimous demand for tariff protection in the hosiery industry. Cotton hosiery and gloves ask for protection to establish large scale production (infant industry)	No particular amount of tariff duties suggested
(h) The Lace Industry [5]	Same situation as above. Machine lace industry in need of protection to establish large scale production	No particular amount of tariff duties suggested

[1] Departmental Committee Appointed by the Board of Trade to Consider the Position of the Electrical Trades After the War, *Report*, 1918 (Cd. 9072), pp. 8, 9 and 12.

[2] Same, Engineering Trades, *Report*, 1918 (Cd. 9073), p. 37.

[3] Same, Iron and Steel Industries, *Report*, 1918 (Cd. 9071) pp. 28–32. Two members of the Committee dissented from the majority opinion that protection would be necessary after the War.

[4] Same, Shipping and Ship-building Trades, *Report*, 1918 (Cd. 9092) pp. 28–9.

[5] Same, Textile Trades, *Report*, 1918 (Cd. 9070), pp. 122–4.

lowing the War, shows us the extent to which this was true.[25] Only one, shipbuilding, was opposed in any strenuous way to the proposal of tariff protection; most of the others, save cotton, were apparently strongly in favor.[26] The same conviction among business men, that protection following the War would be highly beneficial, had been expressed earlier for certain of the minor industries.[27] Beyond a doubt, a general sentiment was being crystallized among industrialists in favor of fiscal revision, if not in favor of adopting a comprehensive tariff system.

THE IMPERIAL CONFERENCE OF 1918 AND THE CLOSE OF THE WAR

These recommendations of the Balfour of Burleigh Committee did not lead to immediate action on the part of the Government, for it was commonly understood that no action was to be taken until after the close of the War. They were, however, considered by the Imperial War Conference of 1918, and were made the basis of a number of "practical resolutions," in the form of recommendations for consideration by the respective Governments of the Empire.[28] The recommendations constituted a large scheme for the economic development of the Empire, and were approved unanimously.[29] The chief concern behind them, according to Mr. Hewins, was Imperial development during the period of reconstruction, the duty of the British being first to set their own house in order. Representatives of the Empire at the approaching Peace Conference could be guided thus in defining their position.[30]

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[25] See citations at foot of Table I.

[26] It is significant, perhaps, to point out here that the number of persons employed in the industries favorable to protection was roughly 14 per cent of the total number of persons gainfully employed, in June, 1921. This figure has been obtained from a study of population statistics contained in the Committee on Industry and Trade, *Survey of Industrial Relations*, pp. 403–15.

[27] Sub-Committee to Advisory Committee of Board of Trade, *Report*, *op. cit.*

[28] Mr. Hewins was Chairman of an Economic Committee of the Imperial War Conference which drafted the recommendations. See his book, *op. cit.*, pp. 44–5.

Shortly after the War came to a close, there followed the famous election of 1918, by which Mr. Lloyd George was returned to power at the head of a new Coalition Government. Like its predecessor, it was a compromise, and because of this, did not submit the resolution of the 1917 Imperial War Conference to the House of Commons, as would have been the constitutional procedure.[31] It was clear, however, what position the new Government would take on this question. Mr. Lloyd George had addressed the Lord Privy Seal prior to the formation of his election manifesto:[32]

> I have already accepted the policy of Imperial Preference as defined in the resolution of the Imperial Conference to the effect that a preference will be given on existing duties which may subsequently be imposed. As regards other aspects of this problem, I am prepared to say that the "key" industries on which the life of the nation depends must be preserved. I am prepared to say also that in order to keep up the present standards of production and develop them to the utmost extent possible, it is necessary that security should be given against the unfair competition to which our industries have been in the past subjected by the dumping of goods below the cost of production. Beyond this I should say we must face all of these questions with new eyes, without regard to pre-war views or pre-war speeches. The object which we have in view is to increase to the greatest possible extent production in this country. . . .

THE INTRODUCTION OF PREFERENCE INTO BRITISH TARIFF LEGISLATION

When Parliament met again, it was announced that a bill would be introduced shortly for the prevention of dumping.[33] None appeared and the proposal was forgotten temporarily upon the presentation of the Budget, introduced by Mr. Austen Chamberlain, then Chancellor of the Exchequer. Here it was proposed to allow preferences upon a number of existing duties.[34] The range of duties upon which preference was to be granted was not large, and no proposal was made to increase their number, a procedure which is said to have side-tracked free trade opposition. But Mr. Chamberlain observed with some significance in his Budget speech that: "Though the beginnings be small, there are vast opportunities for the development of British Imperial trade to be secured by promoting that trade along the line of preference." [35] In other words, this was merely, in his conception, a first step. Included in the plan was a preference grant of one-third on the McKenna duties, which were to be continued; a preference grant of one-sixth on tea, coffee, sugar, and motor spirits; and a preference of varying rates upon wines and spirits. The approval of Parliament being gained subsequently, the British Government had given concrete expression, finally, to its war-time admission of the principle of Imperial preference.

THE APPEARANCE OF SAFEGUARDING

Following suggestions which had been made consistently during the War period, for the exclusion of certain imports during the years immediately following the cessation of hostilities, in order to afford British industry an opportunity to recover, effort was made by the Coalition Government to continue the controls and embargoes established for emergency purposes. No less than two hundred and sixty classes of goods, writes Mr. Hirst, were either prohibited or were allowed to enter British ports only in restricted quantities under licenses granted by the Board of Trade.[36] This practice was the cause of no little criticism. Lord Parmoor, in the House of Lords, asserted that these embargoes and licenses were illegal. A crisis was reached just before Parliament adjourned, in August, when Sir John Simon announced his intention of importing certain prohibited goods from Spain.[37] A few days later, Mr. Lloyd George told the House of Commons that the policy was to come definitely to an end on September 1, explaining that it had been retained merely to shield industries during the period of demobilization, and that no further justification for it appeared to exist.[38]

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[29] *Proceedings of the Imperial War Conference, 1918*, (Cd. 9177), pp. 4–9.

[30] Hewins, *op. cit.*, p. 45.

[31] *Ibid.*, p. 46.

[32] Quoted in *Parliamentary Debates*, Commons, Vol. 114, 1919, Col. 323–4.

[33] King's Speech quoted, *Ibid.*, Col. 326.

[34] Budget Speech, *Ibid.*, Vol. 115, Col. 198–9.

[35] Budget Address, *Ibid.*, Col. 195.

When Parliament met again, the Coalition Government introduced an anti-dumping bill. It received little support and consequently, was not pushed. There was arising considerable opposition to the continuance of Government domination in business, which had come to obtain because of the War. This fact was one of the chief subjects of controversy during 1920. A return to free trade sentiment was occurring. It even appeared that the Government proposals for the protection of certain "key" industries would be rejected when introduced.[39] Such a complete reversal of sentiment, however, did not come about, as was evidenced by the acceptance of the Dye-stuffs Import Regulation Bill which was introduced in December.[40]

The passage of this act prepared the way and assured the introduction of the Safeguarding of Industries Bill. Compelled by the pressure of its Conservative participants, the Lloyd George Coalition finally offered two resolutions in the House of Commons to make good its election promises.[41] The first provided that a customs duty of 33.3 per cent *ad valorem* should be imposed upon nine classes of articles whose manufacture was considered to be essential to success in war. These "key" articles included optical glass, laboratory porcelain, hosiery latch needles, metallic tungsten, and all synthetic organic chemicals. The second resolution provided that a similar duty should be imposed on articles offered for sale in the United Kingdom at prices below their cost of production, or at prices below those at which similar goods could be manufactured in the Empire, owing to a depreciation of currency in the country of origin. Manufacturers desiring protection under the second resolution were to apply to the Board of Trade, who would appoint a committee to survey the facts of their case, and report. The Board of Trade, upon a favorable report, could then issue an order authorizing the application of the duty, allowed under the second resolution, for three years. Such an action by the Board of Trade was subject to confirmation by Parliament. Duties for different reasons could be levied simultaneously, but the total could not exceed 66 per cent.

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[36] Hirst, *op. cit.*, pp. 64–5.

[37] *Ibid.*, pp. 65–6.

[38] *Parliamentary Debates*, Commons, Vol. 119, 1919, Col. 2009–10.

[39] Hirst, *op. cit.*, p. 67.

[40] *Public Bills*, Vol. I, 1920, Bill 269. This bill made the importation of dye-stuffs illegal save under license.

[41] *Parliamentary Debates*, Commons, Vol. 142, 1921, Col. 867.

The Bill embodying these resolutions was not finally passed until August, 1921.[42] As Mr. André Siegfried has described it, it was "a regular Protectionist arsenal."[43] Its passage is extremely important, because it represents the climax reached by the protectionist movement arising directly out of the War. Furthermore, it was the last act to be justified by the Paris Resolutions.[44] To be sure, under Part I of the Bill, which went into force, October, 1921, duties were imposed for only five years; and under Part II, they could be levied for only three years. In addition, the minute precautions of the second half, made its application most difficult. A large number of articles were added, nevertheless, to the British tariff list by Part I. So many, in fact, that Mr. Hewins was led to assert: "After the passage of this Act, it was, of course, absurd to suggest that this country any longer retained the Free Trade system."[45]

The War left many marks upon British institutions; and not the least important of these was the change affected in the fiscal system. This change might have proved to be a temporary one, which would be eradicated in the course of time. Our next chapter, therefore, will treat of the movement up to the present time.

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[42] *Public Bills*, Vol. I, 1921, Bill 183.

[43] Siegfried, A., *Post-War Britain*, (N. Y., Dutton, 1924), p. 25.

[44] *Parliamentary Debates*, Commons, 1921, Vol. 146, Col. 843–922.

[45] Hewins, *op. cit.*, p. 50.

CHAPTER III

RECENT MANIFESTATIONS OF PROTECTION, 1921 TO 1927

FOLLOWING the passage of the Safeguarding of Industries Act, the tariff schedule of Great Britain included, first, the old revenue duties which had long existed as part of the British fiscal system; second, the McKenna duties which had been applied continuously since their introduction in 1915; third, duties upon numerous articles which came under Schedule I of the new Safeguarding of Industries Act. Preferences of varying amounts were allowed upon these three groups of duties. Finally, there existed Schedule II of the new Act, the application of which we have not considered as yet. Admittedly, such a tariff schedule contained a more extensive commodity protection than a staunch Liberal free trader would have liked. Much of it represented a compromise between the two principal parties during the years of critical emergency; it was not the result of a deliberate program of the Conservative Party. Therefore, the years following the War might well have witnessed its obliteration. No such thing occurred, as we shall see in this chapter.

THE APPLICATION OF THE SAFEGUARDING OF INDUSTRIES ACT, SCHEDULE II

Shortly after the passage of this Act, several industries made application for inclusion under Schedule II which embodied the second resolution on safeguarding introduced by the Lloyd George Coalition Government. They alleged that German competition was made possible by that country's depreciated currency. The Board of Trade appointed committees to investigate, and their findings being in the affirmative an Order was issued subsequently by the Board granting the industries protection. Among those allowed relief by this means were the manufacturers of fabric gloves, glove fabrics, domestic glassware, and domestic hollow-ware of aluminum or enameled iron or steel.[1] Another Order was issued shortly including gas mantles for the same reason.[2] No other inclusions were allowed, although a number of applications were received. This was due in part to the difficulties encountered by investigating committees in their efforts to determine whether goods were being sold below their cost of production in countries of origin, owing to the depreciation of their currencies.[3] It was also due to the official British interpretation of commercial treaties. Duties under this section of the Act could be allowed only against goods imported from Germany, because no commercial treaty was in existence with that country.[4] Again, because of these treaty complications preferences could not be granted under Schedule II.[5]

After a year's existence, the Safeguarding of Industries Act had fallen into serious disfavor. It did not seem to be accomplishing those things which had been promised for it. British trade and commerce, had sunk into severest depression. Apparently, the sentiment against protectionism had grown quite intense, for when Mr. Lloyd George's Government fell, Mr. Bonar Law pledged that, if he were returned to power, there would be no further change in the fiscal system of the country.[6] Security and confidence, which were so essential to Britain's recovery, he asserted, could be obtained best by refraining from any experiment; but he, of course, believed that she would profit by a change in the long run. He also pledged that fiscal policy was not an issue of the election, and that his party would take no steps in that direction without a mandate from the electorate. Such a pledge from a leading protectionist politician may be reasonably interpreted as reflecting a popular reaction against additional tariff reform.

THE IMPERIAL ECONOMIC CONFERENCE OF 1923

Mr. Bonar Law had also announced his adherence to the policy of Imperial Conferences, during the campaign preceding his election. The last Conference had been held in 1921, but had not considered the usually commanding problem of protection and Imperial preference.[7] An Imperial Customs Conference had met at the same time but had dealt with only minor problems of technical uniformities.[8]

Upon his return to office, Mr. Law announced the meeting of another Conference to consider political problems of the Empire, and at the same time, an Imperial Economic Conference to treat economic problems. Because of his pledge upon protection, however, the probable success of any consideration of the preference question by the Conference was greatly jeopardized. As the situation stood, a Conservative Government, which had been tied to an Imperial policy since 1907, apparently did not intend to propose any measures of a fiscal nature to render that policy effective.[9]

Preparations for the two Conferences progressed, and a date was set for their meeting in October, 1923. The Empire Development Union, an official organization which had been formed to develop an Imperial economic policy, cabled the circumstances to the Governments of the various Dominions, and requested that they come to the Conferences prepared to consider and evolve only concrete schemes for Imperial expansion.[10] Preference proposals, among other topics which might be considered, were suggested by this communication.

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[1] Order No. 1, *Board of Trade Journal*, Vol. 109, pp. 141–2.

[2] Order No. 2, *ibid.*, p. 418.

[3] Hewins, *op. cit.*, p. 49.

[4] *Ibid.*, p. 177.

[5] *Ibid.*, p. 50.

[6] Speech in South London, Nov. 7, 1922. See *The Times* (London), Nov. 8, 1922.

[7] *Proceedings of the Imperial Conference*, 1921 (Cmd. 1474).

[8] *Proceedings of the Imperial Customs Conference*, 1921 (Cmd. 1231).

[9] Hewins, *op. cit.*, p. 57.

Several months before the Conference was scheduled to meet, ill health forced Mr. Bonar Law to resign the premiership, and he was succeeded in office by Mr. Stanley Baldwin, who set out to follow his predecessor's policies. For a while, he appeared to be successful in his purpose, and no fiscal changes with regard to duties were suggested in the Finance Bill of 1923.[11] Even the McKenna duties were renewed again, so rigidly did the Conservatives follow Mr. Law's pledge, though Mr. McKenna in a letter to a musical instrument importer complained that the Government had betrayed his purpose in not removing them after the War.[12]

The Imperial Economic Conference met, as scheduled, on October 1st. In one of the opening addresses, Sir Phillip Lloyd-Greame, President of the Board of Trade, urged the need of accelerating the development of Imperial resources.[13] He asserted that, since Great Britain had definitely established the principle of Imperial Preference in her fiscal system, she now wished to apply the principle further within such limits as practicable to achieve the end desired. In the responding addresses of the Colonial Prime Ministers, many favorable comments were made on the efficacy of British preferences. For example, Mr. Mackensie King stated that Canada had been influenced to offer additional preferences by Britain's new attitude.[14] South Africa, according to General Smuts, was prepared to reshape her fiscal policy for greater common advantage.[15] The same sentiment was expressed by the representatives for both New Zealand and Australia.[16]

The British Government was prepared to meet this display of preference approval by some new proposals. Several days later, when the subject was set for discussion, Sir Lloyd-Greame asserted that, since the facts revealed the value of preference so clearly, his Government was now ready to make several offers of further grants.[17] He then proceeded to outline the additional reduction which the Government thought worth while on a group of articles imported from colonial sources; *i.e.*, certain dried fruits, currants, sugar, and tobacco, upon which duties were already in existence, other dried fruits and preserved fruits upon which duties would have to be imposed. The amount of preference on all the above articles save sugar and tobacco was named to be 100 per cent, while on these latter the offer was made of a ten-year guarantee for the maintenance of existing preference rates, with the possible alternative, in the case of tobacco, of an increase in the rate of preference.

The reaction of the colonial representatives is a story in itself. One by one, they arose and expressed their appreciation, and each in turn enumerated a list of additional products which his respective Government would be gratified to have granted preferential entrance into the markets of the United Kingdom.[18] Only the Indian delegate refused to commit his Government to preference, although he saw no reason for actively opposing it. It was a strange occasion, but the representatives of the Crown were equal to it. Their motives are not difficult to divine. For the moment, free trade traditions were discarded or forgotten; the ideals of an economically unified empire took their place. The Conservative Ministers, imbued with a ripe Imperial enthusiasm and stimulated by the all-pervasive nature of British trade depression, rose again boldly and raised their bid for Empire markets. Trade had been suffering the deadliest of ills. Pressure on business and commercial interests had never been so intense. Rumors full of the direst pessimism were current. In short, the time was propitious, the stage was set. There was every reason to believe that the electorate would approve this step in the hope of trade revival.

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[10] Quoted in full, *ibid.*, pp. 57–63. See especially pp. 62–3.

[11] See Mr. Baldwin's Budget Speech, *Parliamentary Debates*, Commons, Vol. 162, 1923, Col. 1737–40.

[12] Quoted by Mr. Hirst, *op. cit.*, p. 79.

[13] *Proceedings of the Imperial Economic Conference*, 1923 (Cmd. 2009), p. 31.

[14] *Ibid.*, pp. 36–7.

[15] *Ibid.*, pp. 47–8.

[16] *Ibid.*, p. 40 and pp. 57–83.

[17] *Ibid.*, pp. 175–8.

The Crown extended its offer by including an additional preference on tobacco; preferences upon raw apples, canned salmon, fruit juices; honey to the extent of 100 per cent; then an increase in the preference on wines and sparkling wines; and finally, a duty to be imposed upon barley and hops with a preference of one-third.[19] Even this Imperial gesture did not entirely satisfy the varied interests represented in the Conference, and each, amid profuse thanks, enumerated still other things upon which a preference would be desirable.[20] It appeared from this proceeding, that, now the British Government had crossed the Rubicon, there would be no end to the demands made upon it. In final approbation of the British preference proposals, the Conference unanimously reaffirmed the Preference Resolution of 1917.[21]

The above recital is not, however, the entire story of protection as dealt with by the Imperial Economic Conference of 1923. Many other proposals were made, including several untimely ones by Mr. S. M. Bruce, of Australia, for placing duties on, or granting other protection to principal food stuffs and raw materials with preferential arrangements for Empire products.[22] These proposals were, of course, rejected in toto by referring them to a committee which reported unfavorably. The remaining discussion given to protection was devoted to a consideration of confining government contracts to Empire products, with resolutions covering this point presented and passed.[23]

THE FALL OF THE CONSERVATIVES ON THE ISSUE OF PROTECTION

We have already suggested motives for the preference proposals of the Conservative leaders, and subsequent developments tend to verify them. Notwithstanding this, at the time, their proposals were the cause of much conjecture and criticism. Mr. Bruce added to the tenseness already existing in many quarters by publicly insisting that the United Kingdom would reap a profit from duties on foods and materials with preference grants on the same to the Empire.[24] Strong resolutions were passed by the protagonists of free trade in various organizations protesting against the Government's breach of faith.[25]

The Government was not slow in making clear its intentions; and on

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[18] *Proceedings of the Imperial Economic Conference*, 1923 (Cmd. 2009), pp. 183–88.

[19] *Ibid.*, pp. 203–6.

[20] *Ibid.*, pp. 206–34.

[21] *Ibid.*, p. 238.

[22] *Ibid.*, pp. 57–83.

[23] *Ibid.*, pp. 253–4.

[24] See the *Nation* (London), Vol. 34, pp. 110–1.

[25] Hirst, *op. cit.*, p. 81.

October 25th, Mr. Baldwin, in an address to the annual Conservative caucus at Plymouth, announced that, while he regarded the unemployment problem as the most critical one facing the country, he could do nothing about it without a weapon of some sort.[26] After considering all the factors in the situation, he had concluded that "the only way of fighting this subject is by protecting the home market." The Government's position was made still more comprehensible by the following statement in the House of Commons during the debate on the Labor censure resolution. Mr. Baldwin said:[27]

> "What the Government desires is release from the pledge given a year ago, to enable them to impose duties on manufactures generally for purposes of revenue and tariff negotiations, together with the full power to impose larger duties when the circumstances of particular industries require it. The Safeguarding of Industries Act is far too limited in its application to deal with goods from Germany which are today threatening our industry. . . . The Government has come to the conclusion that they cannot deal with this measure sporadically by an act of the nature of the Safeguarding of Industries Act, and that, if you want either to negotiate effectively, or if you want to give dominion preference, or if you want to raise revenue, you must make your duties general, even if they be but duties for revenue purposes."

The election which resulted from this issue was a bitter contest. No complete scheme for a general tariff was advanced in the campaign. A committee sat in secret, however, preparing a specific tariff plan, but no details were published.[28] The issue was the broad one of protection. Food duties, promised Mr. Baldwin, would never be imposed upon essential items. To tempt the farmers, he offered a subsidy paid out of the import duties on manufactures.[29] Whatever the leaders of tariff reform may have anticipated, the campaign, based upon the issues cited fell short in its appeal to the people. When the results were in, the Conservatives found themselves with a minority, and upon the refusal of the Liberals to support them, gave way to the formation of the Labor Government.

THE LABOR GOVERNMENT AND FREE TRADE

Mr. Phillip Snowden, who became Chancellor of the Exchecquer under Mr. Ramsay MacDonald, proceeded to interpret the defeat of the Conservatives as a clear mandate for the resumption of free import practices.[30] Accordingly, in his Budget, he eliminated the McKenna duties, and cut the existing tariff on sugar, tea, coffee and dried fruits. He made no effort to change prevailing preferences, but he denied the right of the former Government to pledge the maintenance of any preferences for specified periods, as had been done at the recent Imperial Economic Conference. As for the resolutions passed by that Conference, he would submit them to the House of Commons and abide by their decision. Finally, with regard to present Safeguarding of Industries duties, under Part II of that Act, he proposed to allow them to run their natural course, since they would terminate shortly.

The Budget was readily accepted by the House of Commons; but some difficulty was encountered in defeating the resolutions of the Imperial Economic Conference. After extended debate, however, the Government succeeded in getting them all rejected, even if by extremely close margins.[31] The ideal of a closely unified Empire was capable, apparently, of arousing strong sympathy and support, even in a situation hostile to a more inclusive protectionism.

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[26] See speech quoted in *The Times* (London), Oct. 26, 1923.

[27] *Parliamentary Debates*, Commons, Vol. 168, 1923, Col. 485–6.

[28] The committee consisted of Viscount Milner, Professor Sir William Ashley, Professor Hewins and one or two business men. See Hirst, *op. cit.*, p. 84.

[29] *Ibid.*, p. 83.

[30] *Parliamentary Debates*, Commons, Vol. 172, 1924, Col. 1598–1604.

THE RETURN OF THE CONSERVATIVES AND NEW PROPOSALS FOR SAFEGUARDING

The Labor Government was not destined to remain long in power, and in November of that year, a defeat at the polls forced its retirement from office. During the election, no issue was raised regarding fiscal policy, but when Parliament reconvened in December, the King announced in His address that: "A bill is under consideration and will be submitted . . . at an early date for safeguarding employment in efficient industries, where the need for exceptional action is established."[32] In defending this course, Premier Baldwin set forth a series of principles which were going to be fundamental in the Government's new safeguarding act.[33] First, any industry, to be safeguarded, must be one of substantial importance, and it must be efficient. Second, an industry to be safeguarded, must be subject to exceptional competition arising from such things as depreciated exchanges, bounties or subsidies, lower wages or longer hours in foreign countries and differences in tax burdens. Third, any duty must be a general and not a particular one, to avoid treaty complications. Fourth, a preference should be granted to the dominions.

No bill was forthcoming, however; the Government evidently had changed its tactics. Early in February, the Board of Trade issued in a "White Paper," the Government's new plan of safeguarding.[34] Under this arrangement, no bill was to be introduced. Instead, the Board of Trade would appoint investigating committees, and upon favorable report by them with the concurrence of the Board and the Treasury, the Government would include their recommendations in the Finance Bill. Duties would be imposed only for a limited period, the plan provided, but this period would vary with each case and would be prescribed by the Government in its finance proposals. The rules to be applied by the Board of Trade when applications are received, were modelled upon the principles set forth by Mr. Baldwin in the House of Commons:[35]

> (1) The Board must be of the opinion that the industry applying for an inquiry in respect of the whole or any part of its production, can reasonably be regarded as of substantial importance on account either of the volume of employment engaged in such production, or of the nature of the goods produced.
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> (2) The Board must be of the opinion that there is *prima facie* evidence that the competition of foreign imports in the industry is exceptional, and that by reason of such competition, employment in the production of goods in question in the United Kingdom is being, or is likely to be, seriously affected.
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> (3) The applicant industry must show that in countries from which competition comes, the conditions in one or more respects set out in paragraph (5) of the Rules hereunder, for the guidance of committees, are so different from those in this country as to render the competition unfair.
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> (4) The Board of Trade will in their discretion, reserve the right to refuse an inquiry, irrespective of other conditions ob-

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[31] *Parliamentary Debates, Commons,* Vol. 174, 1924, Col. 1863–2286.

[32] *Ibid.*, 1925, Vol. 179, Col. 49–50.

[33] *Ibid.*, Col. 1064.

[34] The substance of this "White Paper" is available in the *Board of Trade Journal,* Vol. CXIV, pp. 170–1, or see Board of Trade, *Safeguarding of Industry, Procedure and Enquiries,* 1924–5 (Cmd. 2327).

[35] *Ibid.*, p. 170.

taining in the industry, if they are of the opinion that the industry is not carried on in this country with reasonable efficiency and economy, or that the imposition of a duty on goods of this class or description in question would have a seriously adverse effect upon employment in any other industry, being an industry using goods of that class or description in production.

When the approval of the Board of Trade had been gained, the committee appointed to pursue further inquiry was instructed to report on the following questions:

(1) Whether the applicant industry is, by reason of the volume of employment, engaged in the production of the goods to which the application relates, or by reason of the nature of the goods produced, an industry of substantial importance.

(2) Whether foreign goods of the class or description to which the application relates, are being imported into and retained for consumption in the United Kingdom in abnormal quantities.

(3) Whether the foreign goods so imported are being sold or offered for sale in the United Kingdom at prices which are below the prices at which similar goods can be profitably manufactured in the United Kingdom.

(4) Whether by reason of the severity and extent of such competition, employment in the manufacture or production of such goods in the United Kingdom is being, or is likely to be, seriously affected.

(5) Whether such exceptional competition comes largely from countries where the conditions are so different from those in this country as to render competition unfair. Competition for the purpose of such inquiry is not to be deemed unfair unless it arises from one or more of the following causes:

(a) Depreciation of currency operating so as to create an export bounty.
(b) Subsidies, bounties, or other artificial advantages.
(c) Inferior conditions of employment of labor, whether as respects remuneration or hours of employment, or otherwise obtaining amongst these persons employed in the production of the goods in question, as compared with those obtaining amongst persons employed in the production of similar goods in the United Kingdom.

In making their report upon the alleged unfairness of competition, the committee may call attention to any special circumstances by reason of which, in their opinion, the industry of the United Kingdom is placed at a serious relative disadvantage.

(6) Whether the applicant industry is being carried on in the United Kingdom with reasonable efficiency and economy.

(7) Whether the imposition of a duty on goods of the class or description in question would exert a seriously adverse effect on employment in any other industry, being an industry using goods of that class or description in production.

(8) Whether, having regard to the above conditions, the applicant industry has, in the opinion of the committee, established a claim to a duty; and if so, what rate or rates of duty, in the opinion of the committee, would be reasonably sufficient to countervail the unfair competition.

The appearance of this "White Paper" aroused no little opposition. It justifiably gave rise to numerous accusations that the Government was letting general protection enter through the "back door." A resolution of censure was introduced by Labor on this very issue.[36] But in reply, Mr. Baldwin denied that any such intentions could be inferred from the Government's action; and asserted that they were only carrying on their announced safeguarding policy.[37]

THE CONSERVATIVE BUDGET OF 1925

This policy was merely an expansion of the provisions included under Schedule II of the 1921 Safeguarding of Industries Act. In applying that Act, two committees had been appointed, one to investigate the lace industry, and the other the silk industry. The Government received their reports just prior to the ascendancy of Labor. The Lace Committee had reported unanimously in favor of a safeguarding duty, while the Silk Committee had been divided two against two.[38] No action had been taken, of course, on these reports during the year of Labor rule. Now the way was clear for the safeguarding of those industries. A new Lace Committee was shortly appointed and instructed to determine if the conditions reported by the 1923 committee still obtained.[39] When this committee found nothing had occurred to alter the original findings, the Government offered a resolution amending its finance proposals to allow for this duty.[40]

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[36] See Censure Resolution and Speech by Mr. R. MacDonald, *Parliamentary Debates*, Commons, 1925, Vol. 180, Col. 703-20.

[37] *Ibid.*, Col. 720-6.

As for the silk report, no new investigation was authorized. When Mr. Winston Churchill, Chancellor of the Exchecquer, announced his Budget in the House of Commons, one of his most notable innovations was a sumptuary tax upon imports of silks and artificial silks, raw or manufactured.[41] This, however, was not the full extent of his protectionist proposals. He reëstablished the McKenna duties, claiming the same reasons for their reimposition as were advanced for their original passage in 1915. He further proposed a duty on hops which he frankly declared to be baldly protectionistic. Finally, he announced that the Government intended to carry out in the completest and most precise manner all pledges which had been made at the 1923 Imperial Economic Conference. All of these protectionist projects were incorporated into the Finance Bill of 1925 as it was ultimately passed.

THE NEW SAFEGUARDING OF INDUSTRIES POLICY IN PRACTICE

According to the original safeguarding proposals, any duties suggested, if approved by the Board of Trade and the Treasury, were to be included in the Finance Bill; and with the passage of that act, legislation was evidently to be closed until the next finance measures of the following year.[42] Applications, of course, could be received in the meantime and investigations could be made of the applicant industries. This is what actually took place in the latter half of 1925. A number of industries applied for safeguarding protection, including those concerned with the production of such commodities as superphosphates; brooms and brushes; leather and fabric gloves; cutlery; packing and wrapping paper; gas mantles; and aluminum hollow-ware.[43] Of this group, the applications of the superphosphate industry, the broom and brush industry, and the aluminum hollow-ware industry were rejected. The others were favored with varying rates of duties by their investigating committees. Leather and fabric gloves, for instance, were recommended to receive a 33⅓ per cent duty, as was also cutlery. Packing and wrapping paper, however, was only recommended to receive a duty of about half that amount, 17½ per cent, to be precise, while gas mantles were recommended to receive a flat duty of six shillings per gross.

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[38] See Censure Resolution and Speech by Mr. R. MacDonald, *Parliamentary Debates*, Commons, Vol. 172, 1924, Col. 213.

[39] Board of Trade (Safeguarding of Industries), *Report of Lace and Embroidery Committees*, 1925 (Cmd. 2403).

[40] *Ibid.*, Vol. 184, 1925, Col. 2271–2336.

[41] See Budget Speech, *Ibid.*, Vol. 183, 1925, Col. 66–70.

[42] Board of Trade, *Safeguarding of Industries, Procedure and Enquiries, op. cit.*

[43] See the following reports of the Board of Trade on Safeguarding of Industries; *Report of Superphosphates Committee*, 1925 (Cmd. 2475); *Report of Committee on Brooms and Brushes*, 1925 (Cmd. 2549); *Report of Committee on Leather and Fabric Gloves and Glove Fabrics*, 1925 (Cmd. 2531); *Report of Committee on Cutlery*, 1925 (Cmd. 2540); *Report of Committee on Packing and Wrapping Paper*, 1925 (Cmd. 2539); *Report of Committee on Gas Mantles*, 1925 (Cmd. 2533); *Report of Committee on Aluminum Hollow-ware*, 1925 (Cmd. 2530).

Following these recommendations, the Government determined to take steps for their immediate application. Hence, instead of awaiting the introduction of the Budget to make provision for them, resolutions were promptly moved in the House of Commons (December 2 and 3, 1925) making the duties upon cutlery, gloves and gas mantles effective at once.[44] The resolutions were readily passed with large majorities, though not without strenuous debate upon the general question of protection, and upon whether or not the Conservatives were breaking their election pledge. Gradually, it was claimed by the opposition in this debate, the Government was involving the country in a widespread program of protective tariffs. Where, they asked, was the Government going to draw the line in its safeguarding policy, demarcating it from a policy involving a general protective tariff?

The answer was not long in coming from the Government. A few days after the House of Commons had passed the third reading of these resolutions, Mr. Baldwin announced that an application for safeguarding protection had been refused the iron and steel industries.[45] The reason was, he said, that the repercussion of such protection would have been so far-reaching as to practically set up a general protective tariff in violation of his election pledge. The situation was so serious, however, according to his statement, that, had they been able to consider the iron and steel trades in isolation, the case would have been considered complete.

THE BUDGET OF 1926

The Government, however, did not intend this to denote a relinquishing of its safeguarding policy, nor to suggest that it had any intention of modifying its policy. Later developments clearly evidence that the Ministry was fully determined to continue its pursuit. A committee, appointed to investigate the wisdom of maintaining Schedule I of the Safeguarding of Industries Act of 1921 (relating to the so-called "key" industries), reported favorably.[46] In fact, they recommended its reëstablishment for a period of from five to ten years; its extension to a few additional articles; the increase of the duty rate in the case of optical glass and instruments; and exemption from duty by special Board of Trade order after application and investigation.

At the same time, two safeguarding reports failing to recommend duties were made public, one on worsteds and woolens, and one on enameled hollow-ware.[47] The first one was by far the more significant, for such a grant would have extended safeguarding to one of the important staple industries. Only one requisite was found lacking; *i.e.*, unemployment. The report acknowledged, however, that sentiment was not unanimously in favor of a duty throughout the industry, the woolens group being strenuously opposed. Nevertheless, the committee was so sympathetic to the pleas of those who desired protection that it did recommend a small tariff of 12½ per cent in case future conditions should change so as to make it expedient.

Mr. Churchill's Budget Speech of 1926 followed in the train of this protectionist movement.[48] He proposed to meet the recommendations of the committee which had considered Schedule I of the Safeguarding Act by reenacting its provisions for ten years, raising at the same time, the duties on optical glass and instruments to 50 per cent. In addition, he accepted the request to safeguard wrapping paper by imposing a duty of 16⅔ per cent; reimposed the silk duties, and extended the McKenna duties on motor vehicles from passenger to commercial cars.

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[44] *Parliamentary Debates*, Commons, 1925, Vol. 188, Col. 2273–2474 and 2567–2698.

[45] *Ibid.*, Vol. 189, Col. 1945.

[46] *Board of Trade Journal*, Vol. 116, pp. 476–7.

[47] *Ibid.*, pp. 477–8.

[48] *Parliamentary Debates*, Commons, 1926, Vol. 194, Col. 1687–1709.

Finally, he requested Parliament to pledge the maintenance of existing preferences for ten years, thus making, as he argued, for stability. The Finance Bill as passed included these provisions. Plainly, the Conservative Government did not intend to relinquish its tariff program yet. Every opportunity to advance its cause was being utilized. Safeguarding was the chosen means, selected by that Government to secure its ends, and, at the same time, avoid the broad issue of general protection.

THE IMPERIAL CONFERENCE OF 1926

The meeting of the 1926 Imperial Conference is another event of significance in our record of Britain's protectionist trend. With the story of the last Conference freshly in mind, we approach this one for more evidence of the unremitting pressure which had been forthcoming from this source for closer commercial relations through preference. On the whole, we find this Conference less concerned with the problem than any of the previous ones. Apparently, it deliberately avoided the preference question, content with the approval by the Crown of present fiscal policies. On the other hand, absorbing political questions which demanded the attention of the session may have obscured it as an issue. The Empire was foundering upon the rocks of dominion nationalism. New constitutional definitions of status, therefore, engrossed the main consideration of the Conference.[49]

Due respects were paid, nevertheless, to the importance of preference as a stimulator of Empire trade. Mr. Baldwin, in his address at the opening of the Conference, expressed his confidence that preferences had increased the flow of inter-Imperial commerce.[50] In the series of responses delivered by the visiting dominion ministers, assertions were strongly in favor of it, and many pleas were made for its extension.[51] The members were taking this opportunity to press home their appreciation of an advantage gained in British markets by this policy. Mr. Bruce of Australia, in particular, whom we recall as so ardent a proponent of preference at the preceding Conference, sang its praises with extreme enthusiasm, pointing out the increase in trade between Australia and the rest of the Empire since its adoption. He again urged duties and preference by the United Kingdom on those foods and raw materials which could be so abundantly produced in the Empire. In this sentiment he was supported by other members.

Other economic problems were not without consideration. There had been at work since the preceding Conference several permanent Imperial organizations; for example, the Imperial Shipping Committee, the Imperial Economic Committee, the Imperial Institute, later amalgamated with the Imperial Mineral Resources Bureau, the Imperial Forestry Institute, and the newly established Empire Marketing Board. The efforts of these organizations and the reports compiled by them advantageously supplanted the more formal resolutions of the Imperial Conferences, in bringing about closer commercial relations between the Empire's constituent states. As an illustration, the Merchandise Marks Bill, intended as a subtle preference scheme, had been designed by the Imperial Economic Committee, and was wending its way through Parliament at this very time.[52]

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[49] See the *Report* of the Committee on Inter-Imperial Relations in *The Times* (London), Nov. 22, 1926.

[50] See the opening address of Mr. Baldwin, *ibid.*, Oct. 20, 1926.

[51] *Ibid.*, Oct. 25, 1926.

Institutions and organizations of this kind making for closer Imperial relations were being established, reënforcing with definite proposals and research into facts, the formal declarations of the Conferences. They may be looked at from two points of view; first, as a means of temporarily avoiding further insistence on preference by the dominions; second, as sincere and genuine steps in coöperation which might lead to greater stimulation of the Imperial movement, and consequently, of Imperial preference. The possibilities of the latter being the case loom large in the light of the movement as we have traced it in our study. That preference failed to occupy its usual place in the center of the stage at the Conference can hardly be regarded as evidence of weakening importance.[53]

Its absence, moreover, may be explained from another point of view. Simultaneously with the opening of the Imperial Conference of 1926, there was published a plea for international economic freedom signed by a conspicuous group of bankers and business men of the United Kingdom and other European countries, with one or two signers from the United States.[54] The manifesto urged that sight had been lost of the common economic interests of the world. Further world recovery was being materially delayed by the existence of trade barriers. Whatever its purposes, or however opportune its publication may have been, probably the nature of this manifesto had a salutary effect upon the existing spirit of protectionism. Moreover, it must have had its echoes in the Conference chambers. Indirectly, and in spite of a Government of professed protectionist sympathies, the supporters of free trade raised their voices in a timely statement subtly reminding the colonial delegates of Great Britain's peculiar position with regard to Continental and world trade. The forces of free trade were not impotent, and their strategy may have forestalled further steps toward preferential protection at this 1926 Conference. Had there been such steps, an election upon the issue might have been precipitated.

PROTECTION IN 1927 AND SOME FURTHER COMMENTS

While several safeguarding investigations have been conducted since the passage of the 1926 Finance Bill, *e.g.*, into industries manufacturing hosiery and knitware, tableware of translucent and vitrified pottery, and leather bags and metal fittings, only one of these succeeded in securing a safeguarding duty. In Mr. Churchill's 1927 Budget Speech, provision was made for a 28 per cent duty upon translucent and vitrified pottery with an Empire preference of one-third.[55] Mr. Churchill's protectionist innovations were not confined to one, however. He also extended the McKenna duties to tires, which action, he declared, would give the Liberal Party an excuse for continued existence. In addition, he made provision for the inclusion of non-standard cinema films in the McKenna film duty. For revenue purposes, he increased the duties on matches, unmanufactured tobacco, and wines, making in this latter case, provision for Empire preference both in the actual amount of the duty and in the amount of alcoholic content.

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[52] Imperial Economic Committee, *First Report;* "Marketing and Preparing for Markets of Foodstuffs in the Overseas Parts of the Empire," 925 (Cmd. 2493), pp. 6–7.

[53] For example, the General Economic Sub-Committee on Empire Films recommended ample preference upon cinema films produced in he Empire, *The Times* (London), Nov. 20, 1926.

[54] *Ibid.*, Oct., 25, 1926.

[55] See Budget Speech quoted in *The Times* (London), April 12, 1927, pp. 8–9. Also a summary of Budget provisions in the *Board of Trade Journal*, Vol. CXVIII, p. 414.

One wonders where this method of protection by safeguarding may ultimately lead. So far as the extent of its application goes, the number of workers employed in industries granted safeguarding duties upon Board of Trade recommendations is roughly, as judged by the reports of the investigating committees, about 83,500, not a large number relative to the total number of British workers. A much larger number, roughly 425,000, are employed in industries protected by McKenna duties.[56] Consistent progress on safeguarding may enlarge this number considerably. If the industries protected under Schedule I as "key" industries, are considered, the number of workers in protected industry is further increased by several thousand.[57]

Opposition of a very keen sort naturally has arisen against the extension of protection. Nevertheless, the Conservative Party has had an adequate majority to carry through its policy of safeguarding. Moreover, they have passed the Merchandise Marks Bill, which, upon complaint to the Board of Trade and an affirmative order from it, requires competing goods to be marked as to the country of origin.

In all of these steps, the Government has moved with caution. Yet political antagonists have accused them many times of breaking their pledge to the people. Also, industries affected adversely by the safeguarding policy because the protected industry stands in such a relation to them that their own pecuniary interests have been involved, have been active opponents before the Board of Trade and its investigating committees. As a matter of fact, it is difficult to see from the reports of such committees that adequate scientific evidence has been compiled to establish protection.[58] When we recall the terms of the Government's instructions to them, however, it is conceivable that they have acted fairly in their recommendations.

So much for the course of protection up to the time of writing. We suggested in the concluding paragraph of the previous chapter that the movement might prove to be a temporary one, yielding gradually with the return of peace time conditions. That such a readoption of a free trade system has not taken place the events narrated in this chapter abundantly disclose. Speculation about the future possibilities of protection in Great Britain, consequently, would not be without justification at this point. Let us refrain from it, however, until we have examined the fundamental economic forces at work throughout the whole period. To this task the next two chapters are devoted.

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[56] A statement of the number employed in these industries by the Board of Trade, exclusive of tires, as of July, 1925, occurs in the *Parliamentary Debates*, Commons, Vol. 198, Col. 3017.

[57] Probably to a figure of not more than 600,000. This rough estimate is based upon the figures referred to in the foregoing note, and upon a review of the statistics on the number of people engaged in various industries, as of June, 1921. See Committee on Industry and Trade, *Survey of Industrial Relations*, 1926, pp. 403–15.

[58] Prof. T E. Gregory writes that in no instance has a case for protection been proven. Wrapping paper, he points out, was granted protection on a 5 per cent increase of imports over 1913, which increase is accounted for by the increase in the use of kraft paper, a special paper made abroad and only slightly manufactured in the United Kingdom. Furthermore, this duty was urged by the committee as an experiment. Another industry, making gas mantles, was given protection merely on the plea of national importance. Low wages or unfair competition have been asserted without substantiation of reasonable data. We concur with Professor Gregory, after examining the available published reports, that it appears largely chance whether an industry gets protection or not. See his article, "Tariff Disorders on Their Merits," *Manchester Guardian Commercial, Annual Review of 1925*, p. 29.

CHAPTER IV

GREAT BRITAIN'S PRE-WAR ECONOMIC STATUS AND THE MOVEMENT TOWARD TARIFF PROTECTION

HAVING traced the outward manifestations of the movement for tariff reform up to the present time, we must turn now, as just suggested, to a review of industrial and trade developments in order to gain a complete picture. It will be recalled that we noted the rapid expansion of British trade from 1850 on, and the subsequent slowing up after 1868, which date marks the beginning of a series of movements for tariff reconstruction. A large number of forces, beyond a doubt, were highly influential in shaping the origin and evolution of such movements. Of these forces, none were more important than pecuniary considerations. That is to say, the economic actions of individuals, and hence, of groups, are determined in large measure by their immediate interest in connection with particular bargains. Trade conditions tend to be the barometer of the economic interests of the majority. They are, therefore, especially revealing for our analysis.

EXPORT TRADE BEFORE 1900

While it is not our intention to write a complete analysis of British trade from 1850 to the present time, it does seem desirable for the reader to possess some concept of what changes had taken place during the fifty years prior to the period which it is our intention to describe more carefully. In order to obtain a graphic perspective, Chart 1 has been prepared with the data carried through from 1850 to 1902.[1] In the latter year began the great political struggle for the modification of the free import policy, under the leadership of Mr. Joseph Chamberlain. Export data have been used because they are regarded generally as reliably representing British economic conditions, that country being so predominantly a trading nation. Because of the striking price changes which took place during this period, it has been found desirable, in order to eliminate this disturbing element, to divide the raw figures for each year with the corresponding Sauerbeck Index Number of wholesale prices, the base being an average of prices from 1867 to 1877.[2]

We have given on this chart, six lines in addition to a line drawn to indicate the growth of population. Since the scale upon which the chart is drawn is a ratio scale, the long time movements of these curves may be compared accurately with one another. Two of them, the curves of *coal* and *machinery*

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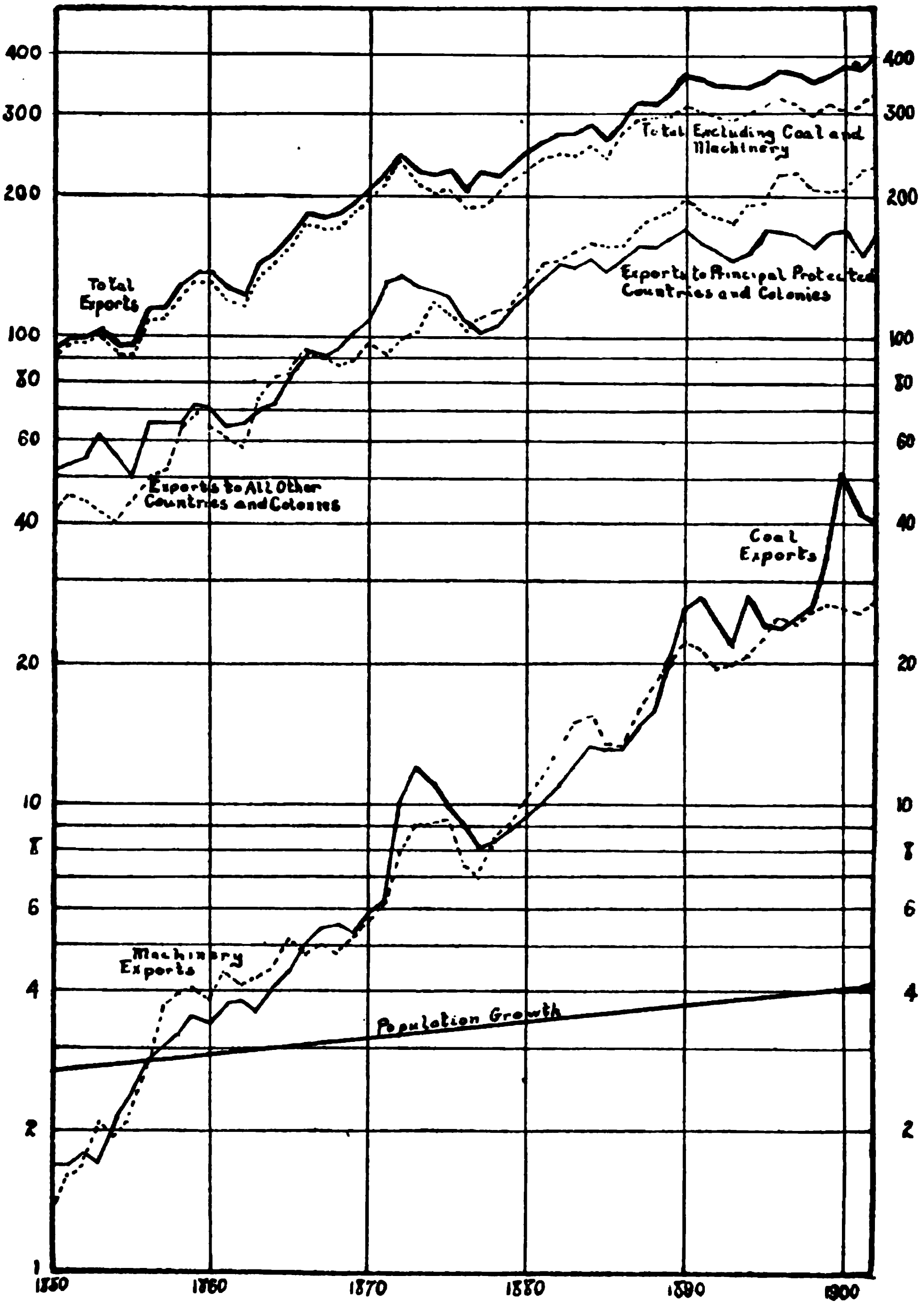
[1] Board of Trade, *British and Foreign Trade and Industrial Conditions*, 1903 (Cd. 1761), pp. 18–9 and 97.

[2] Bulletin of the U. S. Bur. of Lab. Sta., *Index Numbers of Wholesale Prices in U. S. and Foreign Countries*, 1921 (284), pp. 275–81. Prices adjusted by the present writer.

Chart 1—Indicating the Trend of British Coal, Machinery and Total Exports to All Destinations; and of Total British Exports to the Principal Protected Countries and Colonies and to All Other Destinations, in Each Year, 1850–1902

(Adjusted values used. Logarithmic vertical scale.
Unit: £1,000,000)



exports, included here because of their growing importance as exports in this period, show a fairly steep and constant rate of growth for the entire period; that is, their secular trends could best be described by a straight line. For the curves, *all other products* and *total exports*, the trends could best be described by rising lines with a diminishing rate of ascent. Thus, they show for the whole period an increase, but the rate of growth is seen to be decreasing, indicating that the expansion of British trade was meeting with increasing resistance. The rate of growth, however, is still observed to be in advance of population. The rapid rate of growth in *coal* and *machinery exports* was at times the basis of economic pleas for tariff reform. A continuation in the growth in the latter classes of exports, it was urged, indicated an early exhaustion of Britain's basic resources, as well as increasing foreign industrialization; while a decrease in the former revealed that she was hardly maintaining her position in world trade.[3] Dire prophecies, consequently, were made concerning the future of British trade.

The trends of the other two curves, which show the data of *total* exports of British produce to the *principal protected countries and colonies*,[4] and to *all other countries and colonies*, were likewise the cause of some concern to observers.[5] It is evident from the curves that a very pronounced change in the direction of the export trend to the *principal protected countries and colonies* took place after 1872.[6] That is to say, although trade with these countries from that year on continued to increase, the fluctuations were violent, and the rate of long-time growth was greatly decreased, tending to become less than that of population. Export trade to *all other countries and colonies*, on the other hand, increased at a much greater rate, though even here it tended to diminish. This shift, perhaps, may be further illuminated by the use of percentage figures.[7] In 1850, 56 per cent of the exports of all articles of British produce were shipped to those countries designated as *principal protected countries and colonies* and in 1870, 53 per cent, while in 1902, only 42 per cent. Correspondingly, the exports to *all other countries and colonies* increased from 44 per cent in 1850 to 47 per cent in 1870 and 58 per cent in 1902. When only exports of manufactured produce are considered, the former figure fell from 57 per cent in 1850, to 38 per cent in 1902, while the latter rose from 43 per cent in 1850 to 62 per cent in 1902. In addition, the proportion of manufactured exports to total exports was falling in this same period from 96 per cent in 1850 to 75 per cent in 1902 for the *principal protected countries and colonies*, and from 91 per cent in 1850 to 87 per cent in 1902 for *all other countries and colonies*.

IMPORTS BEFORE 1900

Further information concerning the shifts which had occurred in trade may be gleaned by considering net imports.[8] On the whole, they grew almost constantly during the period. On the other hand, imports for reëxport purposes indicated a much lower rate of growth for the twenty-five years prior to 1890 and practically no growth after that date.[9] Apparently, since exports tended to increase at a diminishing rate, a great increase in the invisible items entering into trade was occurring in these latter years to enable payment for the large imports. In other words, although Great Britain was still predominantly industrial, her imports were being paid for more and more by means of the income from financial, commercial and shipping transactions of all sorts. Moreover, the continual growth of imports was being constituted each year of a larger proportion of manufactured goods, amounting, for example, to 11 per cent of the net imports in 1860 and 25 per cent in 1902. That is to say, other countries were offering more and more of their manufactures in exchange for British manufactures and services; whereas formerly they had offered mainly foods and raw materials.

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[3] Ashley, *op. cit.*, pp. 259–63.

[4] The *principal protected countries and colonies* include Russia, Germany, France, Belgium, Holland, Spain, Portugal, Italy, Austria-Hungary, United States, Canada and Victoria. Belgium and Holland are included because a large part of their imports pass on into Germany. See Board of Trade, *Report on British and Foreign Trade and Industrial Conditions*, 1903 (Cd. 1761), p. 13.

[5] Cunningham, W., *The Rise and Decline of the Free Trade Movement* (Univ. Press, Cambridge, 2nd ed.) pp. 107–8,

[6] In interpreting these curves, the reader is cautioned to keep in mind that boundary changes, especially from the expansion of the British Empire, have had an important influence on the figures.

[7] Board of Trade, *British and Foreign Trade and Industrial Conditions*, *op. cit.*, pp. 16–7,

[8] *Ibid.*, pp. 99–104 and 403–4,

This change could work no ill effects upon British trade in itself, providing sufficient foods and raw materials were imported from the same or alternative sources, the manufactured goods being in excess of the essentials for sustaining a growing industry. But when we consider more closely the possible nature of the increased importations of manufactured goods, an element of friction appears. In many cases, they probably consisted of desirable goods not generally produced in Great Britain, or at least, more cheaply abroad. In some cases, the importations were doubtless variations and refinements in the quality of common products, not duplicated by British manufacturers. When such conditions obtained, there was a sound basis for the existing system of trade. There may have been in many instances, however, and probably were, manufactured goods imported of an actively competitive nature. When this occurred, and where such competition was felt, the friction which the British economic machine ordinarily encountered without necessity of adjustment was manifoldly increased. In such fields, the soil was fertile for the germination of the seeds of protection such as bloomed in the Chamberlain campaign.

BRITISH FOREIGN TRADE FROM 1900 TO 1914

Subsequent developments in British foreign trade throw additional light on an understanding of the tariff reform movement during the immediate prewar period. The general character of that trade may be seen in Chart 2, which shows the annual net imports and total exports of United Kingdom produce, divided into classes, adjusted values being used with 1900 as a base.[10] For example, the trend of imports of the *food, drink and tobacco* curve, it is seen, accords closely with the line of population growth. Exports of this class, however, increased faster than did population, and may be accounted for by the increased exportation of manufactured foods, excluded from classification as manufactured goods because of food qualities. Relative to the total this class is small.

Again, imports of *raw materials and articles mainly unmanufactured* show a greater rate of increment than population, indicating industrial gains. Exports of this class, on the other hand, consisting largely of coal, show a diminishing rate of growth after 1909, but this diminution did not fall below that of population for the remaining period.

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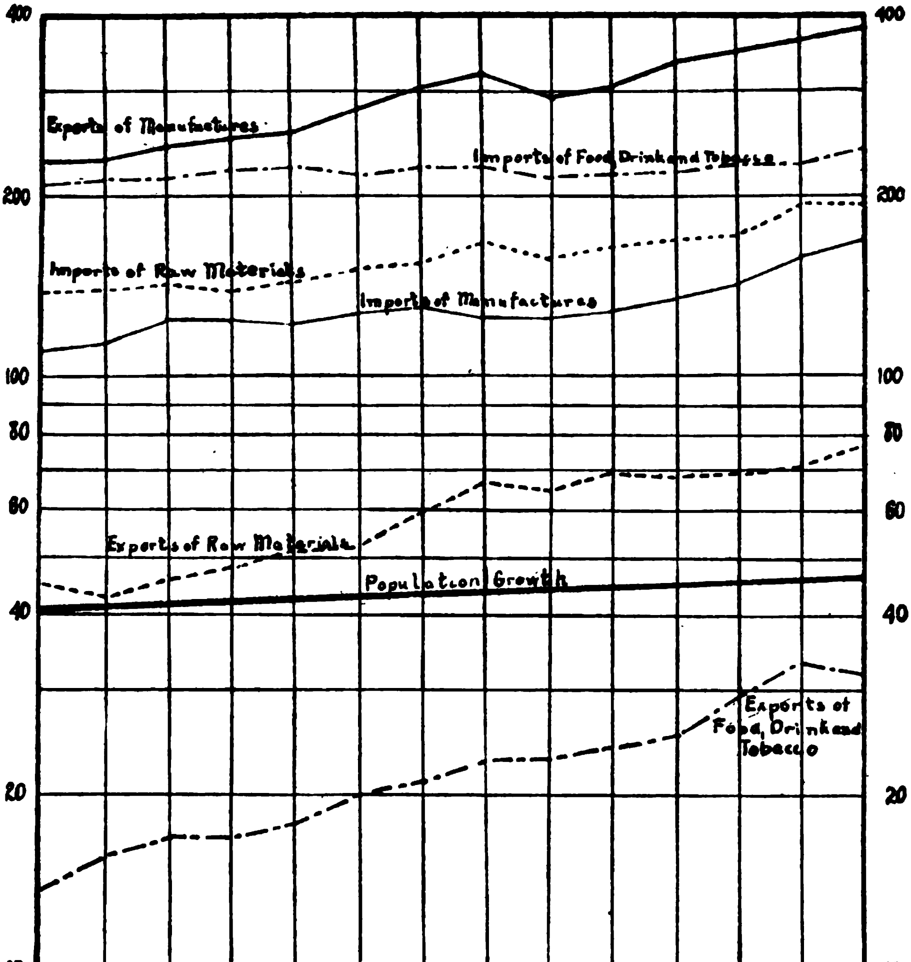
[9] Falling from 12 per cent of total imports in 1854 to 10.6 per cent in 1902.

[10] Adjusted by the Board of Trade. See its memorandum, *Imports and Exports at Prices of 1900*, 1914 (Cd. 7432), pp. 30–1.

CHART 2—SHOWING THE NET IMPORTS AND TOTAL EXPORTS OF BRITISH PRODUCE, DIVIDED INTO CLASSES, IN EACH YEAR, 1900–13

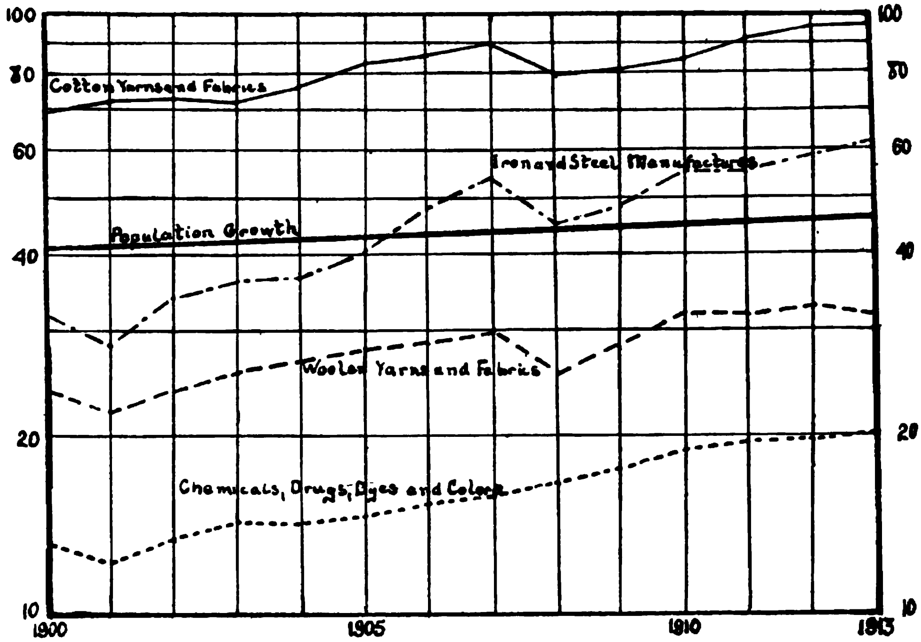
(Adjusted values used. Logarithmic vertical scale.
Unit: £1,000,000)



The curves of exports and imports for the third class of goods, *i.e.*, *articles wholly or mainly manufactured*, are especially interesting, for over one-fourth of the total value of the 1913 imports, and over three-fourths of the total value of the 1913 exports were included in this class. The course of the imports reveals a consistent upward swing for the entire period, with deflections occurring in the years 1907, 1908 and 1909. The rate of growth is much greater than the rate of population growth. The exports curve (for this class), while fluctuating considerably from year to year, also reveals a steady upward trend, apparently, at a greater rate of increase than is indicated by the imports curve. Since the exports of this class of goods are made largely of

CHART 3—SHOWING BRITISH EXPORTS OF (1) IRON AND STEEL MANUFACTURES; (2) COTTON YARNS AND FABRICS; (3) WOOLEN YARNS AND FABRICS; AND (4) CHEMICALS, DRUGS, DYES AND COLORS, IN EACH YEAR, 1900–13

(Adjusted values used. Logarithmic vertical scale.
Unit: £1,000,000)



the products of the great staple industries, these figures would seem to show a rather healthy state of affairs in the major portion of industry. A rejuvenation had plainly taken place in British foreign trade.

EXPORTS OF FOUR STAPLE MANUFACTURES

An additional chart, Chart 3, enables the pursuit of further analysis into the condition of exports of four of the great staple industries.[11] The four principal groups of articles (*mainly or wholly manufactured*) representative of these staple industries are: (1) *iron and steel*;[12] (2) *cotton yarns and fabrics*; (3) *woolen yarns and fabrics*; (4) *chemicals, drugs, dyes and colors*. The trend for the first two named increased regularly for the whole period, and were both greater than population growth. Prior to 1907, however, the rates of growth for both classes of staple exports were higher than in the later years; and in the former years the rate of growth was greater for *iron and steel* than for *cotton yarns and fabrics*, while in the later years, the growths were approximately the same. Of the other two curves, the one representing exports of *chemicals, drugs, dyes and colors*, increases consistently for the entire number of years.[13] This is especially interesting

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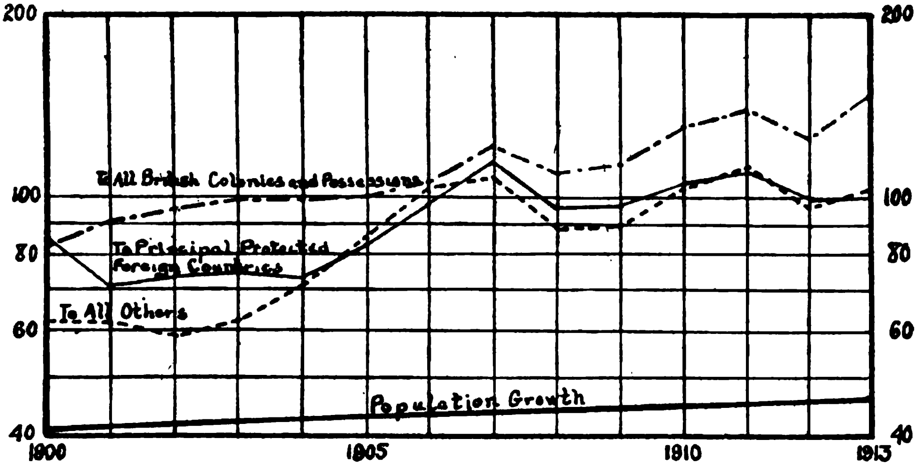
[11] Board of trade, *Imports and Exports at Prides of 1900, op. cit.*, pp. 36–7. These values likewise have been adjusted for prices by the Board of Trade.

[12] Producers in the iron and steel and woolen industries, it will be recalled, were in favor of protection in the war period. See above, pp. 205–206.

[13] According to British official opinion, the progress of the chemical industries in the pre-war period was very limited. See quotation, *infra*, pp. 73–74.

Chart 4—Showing the Distribution of British Manufactured Exports Between the Principal Protected Foreign Countries; all Dominions; Colonies and Possessions; and All Other Destinations, in Each Year, 1900–13

(Adjusted values used. Logarithmic vertical scale.
Unit: £1,000,000)



when we recall that it was in this period that the German chemical industry was developing into the greatest in the world. The curve representing exports of *woolen yarns and fabrics* reveals the least healthy condition. While the rate of accession, for example, prior to 1907, is greater than that for population, after the depression of 1907 and the recovery of 1908 and 1909, the curve levels off, and shows neither a marked decline nor incline for the remaining four years. Apparently, this industry was having difficulties in maintaining its export position.[14]

The Distribution of British Export Trade

In order to appreciate the shifts that were taking place among markets for British goods, especially *protected and other markets*, we have prepared Chart 4, which, as distinguishable from the similar curves on Chart 1, gives only data for manufactured exports.[15] This enables a more accurate picture, perhaps, since these are the classes of goods against which tariff barriers are erected. Differing from the previous curves again, this group is divided between three, instead of two destinations, *e.g.*,

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[14] It is to be noted that the present writer has made no effort to make a comparative study of the exports of Great Britain's staple industries and those of other great industrial nations, and to prove thus the comparative decline of Great Britain, as is often done; *i.e.*, Drage, *op. cit.*, Chapter 4, and Hewins, *op. cit.*, Chapters 8 and 9. The writer is not convinced that such discussion is at all fruitful, or that such comparisons prove anything in particular, save that an industrial civilization may be acquired by almost any nation possessing the energy, intelligence and natural resources.

[15] Board of Trade, *Return Showing the Value of Manufactured and Partly Manufactured Articles (Domestic Produce) Exported from the United Kingdom,* (a) *to the Principal Protected Foreign Countries;* (b) *to all British Colonies and Possessions;* (c) *to All Other Destinations for the years 1800, 1885, 1890, 1895, 1900 and for each subsequent year to 1911,* etc., 1912–13 (536); p. 3. Also, *Annual Statement of Trade of the United Kingdom with Foreign Countries and British Possessions,* 1913, Vol. II, 1914 (Cd. 7585), pp. 20–5.

(1) *the principal protected foreign markets;* (2) *all British colonies, dominions, and possessions;* (3) *all other destinations.* The values used have been adjusted on 1900 as the base year by the Board of Trade.

It is to be noted from the chart that it is impossible to describe the curve of this class of exports to the *principal foreign protected markets* by any particular sort of upward trend prior to 1904. British trade to these markets was evidently barely holding its own, and registering no increase. Expressed in per capita terms, in other words, this trade was declining. From 1904 to 1907 it recovered and even showed a remarkable vitality, slumping again in 1908 and 1912. Unquestionably, the exports of British manufactured goods continued to be severely handicapped by tariff barriers, as well as by the competing industrial technique which was developing behind them, other circumstances being propitious.

This does not mean that tariff barriers were the sole obstacle to a larger expansion of British export trade in this period. The curve of exports to *all other destinations* indicates that this was not the case. For example, after 1904 this curve fluctuates around the curve of exports to the *principal protected foreign countries.* The extension of competition is suggested by this as becoming a factor of growing importance. For the entire period there is an upward trend observable at a somewhat greater rate than that of population growth. Severe fluctuations tend to conceal it. These markets were patently very erratic absorbers of British manufactured goods.

Turning to the third curve, that of exports to *British dominions, colonies and possessions,* we see the most consistent trend of all. It will be recalled that the self-governing dominions were engaged in altering their tariff systems during this period. In some cases increasing barriers were erected, but, at the same time, preferences were being granted and extended to British manufacturers. Whatever the effects these changes may have had, we may believe, at least, that trade with *the colonies and possessions* in this period was characterized by a long-time consistency which other trade lacked.

Too much stress must not be placed upon this fact, however, lest we be drawn into the error of concluding hastily as to the growing importance of Empire trade in relation to the whole of British exports of manufactures. Nevertheless, in terms of percentages of total manufactured exports, Empire exports which grew from 35.8 per cent in 1900 to 41.8 per cent in 1903, fell off to 35.2 per cent in 1906, from which percentage they gradually rose until in 1913 they amounted to 42.2 per cent of the total.[16] Those to *all other destinations* acted in an opposite fashion, being 27.3 per cent in 1900, reaching 33.2 per cent in 1906 and subsequently declining to 29.5 per cent in 1913. Manufactured exports to *principal protected foreign countries,* furthermore, falling sharply from 36.9 per cent in 1900 to 31.7 per cent in 1901, tended to retain a fair stability around this figure until 1910, when they again fell off, reaching 28.3 per cent in 1913. Thus, while the percentage changes were not extremely marked, with allowances for the year to year shifts, it does appear reasonable to conclude that they thoroughly substantiate our previous conclusions. Empire trade throughout the period was slightly the largest proportion of the total trade as against trade with the principal protected markets and trade with all other markets. Finally, in terms of annual averages, the Empire trade of these fourteen years was much higher than that of the ten years previous, the average annual percentage of manufactured Empire exports to total exports for that decade being 33.6 per cent, while the average annual percentage from 1900 to 1913 was 38.8 per cent.

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[16] These figures have been compiled from the data contained in the Board of Trade *Return, Ibid.*

UNITED KINGDOM IMPORTS FROM EMPIRE SOURCES

Because of the understanding such analysis as the foregoing adds to the full comprehension of the momentum gained by the preference movement in the pre-war era, it seems desirable to pursue it even further. For example, the question arises at this juncture whether or not Great Britain was becoming increasingly dependent upon the colonies and possessions for her food and raw materials. An answer to this may be found by analyzing net imports from Empire sources as percentages of total net imports.[17]

Total net imports of all Empire produce increased from 21 per cent in 1900 to 25.2 per cent in 1910, dropping to 25 per cent in 1912. This increase is accounted for entirely by an increase in imports of food, drink and tobacco. Empire products were 19.2 per cent of the total of that class of imports in 1900, and, after a more or less regular climb, were 28.6 per cent in 1912. On the other hand, Empire raw materials as a percentage of all imported raw materials contained a very small, if any, element of growth, the percentage tending to fluctuate about its average of 29.1 per cent. A similar tendency is evident for imported Empire manufactures as a percentage of total manufactured goods, which fluctuated about its average of 11.7 per cent.

Such a change holds considerable interest for us in our analysis. Though Great Britain did not suffer any increased dependence on the Empire for raw materials or manufactures, there was a marked increase in her dependence upon the Empire for food. Whether dependence on the former increased or not, it is significant enough that these classes of imports remained stable while the proportion of food imports from Empire sources had increased. Great Britain's unique industrial system with its highly concentrated population had made the problem of securing food supplies an equally, if not more vital problem to that of obtaining raw materials for her manufacturing operations.

IMPORTS AND EXPORTS OF THE EMPIRE

In order to obtain still another slant upon the problem, let us seek an answer to the question: Were the various members of the Empire growing more or less dependent upon the United Kingdom and upon each other? A brief answer may be obtained by treating in summary fashion the exports of all British *dominions, colonies, possessions and protectorates* with regard to their destinations, and their imports with regard to their source. For greater clarity, percentage figures of total exports and total imports will be used. While the data are not sub-classified, exports consisted mainly of raw materials and food, and imports were made up largely of manufactured goods.[18]

Considering first Empire exports in general terms, the changes in the percentage distribution of these exports between the United Kingdom, the various portions of the Empire itself, and foreign countries, were not great. Take, for instance, exports to the United Kingdom: for the first six years from 1900 to 1905, the average annual share was 42.5 per cent, which figure grew to 44.1 per cent for the remaining seven years. The average annual share of the United Kingdom for the whole period was 43.3 per cent. As for inter-Empire exports, exclusive of the United Kingdom, they averaged 18.9 per cent for the first seven years from 1900 to 1906, then dropped for the remaining six years, averaging but 14.7 per cent of the total. The average annual proportion of Empire exports to foreign countries, finally, acted contrariwise from that for inter-Empire trade, being 38.5 per cent for the period 1900 to 1906 and 41.4 per cent from the latter year to 1912. On the whole, Empire trade does not appear from these figures to have grown more interdependent, although the slight growth in the percentage taken by the United Kingdom may be ascribed some importance for the interpretation of the preference movement. It should be remembered, however, that a similar percentage growth occurred in Empire exports to foreign countries and a decrease occurred in the proportion of inter-Empire exports.

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[17] These figures have been computed from data found in the Board of Trade, *Statistical Abstract for the United Kingdom, from 1899 to 1913*, 1914–16 (Cd. 7636), pp. 166–7 and *Statistical Abstract for the British Empire, from 1898 to 1912*, 1914 (Cd. 7241), pp. 97–8.

[18] These percentages have been computed from data taken from the Board of Trade, *Statistical Abstract for the Several British Self-Governing Dominions, Crown Colonies, Possessions and Protectorates, from 1898 to 1912*, 1914 (Cd. 7165), pp. 54–5 and 60–1. (Including exports and imports of bullion and specie.)

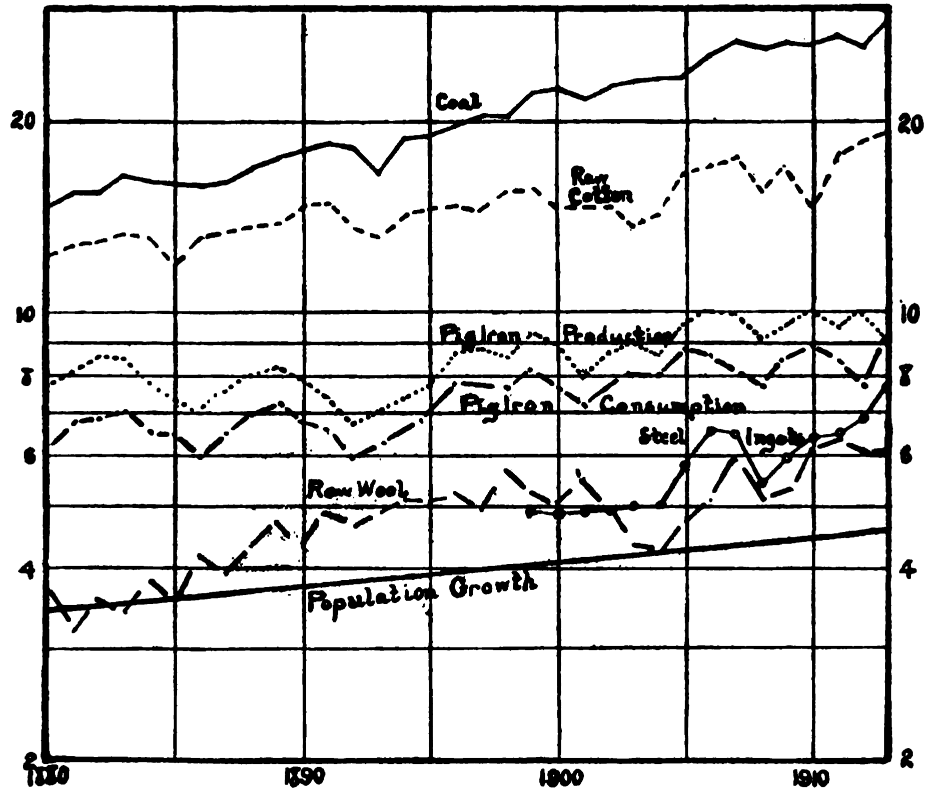
More significant information is revealed by the treatment of imports. The imports of the Empire from the United Kingdom declined from an average annual proportion of 47 per cent for the three years, 1900, 1901 and 1902 to 40.5 per cent for the year 1912, the average annual percentage for the entire period being 44.8 per cent. Imports from Empire sources, as would be expected from our analysis of exports, also registered a decline from an average annual figure of 19.9 per cent for the first five years to one of 16.7 per cent for the remaining eight years. The percentage imported from foreign countries, on the other hand, manifested a notable disposition to increase, rising from 33.9 per cent in 1900 to 36 per cent in 1907 and 44.5 per cent in 1912. This change in the distribution of Empire imports suggests that the colonies and possessions were becoming less dependent upon the United Kingdom, and also less dependent upon each other as time went on. This aspect must not be unduly stressed, however, because the colonies were still dependent for over 40 per cent of their export and import trade on the mother country in 1912, and this is no small percentage. Moreover, 15 per cent more of their trade was among themselves. The Empire was beyond a doubt materially inter-dependent. Yet we must not forget that the 45 per cent of their trade still unaccounted for was with foreign countries, and that this latter portion was growing rapidly, containing a probable element of increased competition for the British manufacturer. It does not seem unreasonable to conclude in the light of these and the foregoing facts of Empire trade, that certain Imperial forces, along with others, were becoming favorable to the protectionist program.

INDEXES OF PRODUCTION

Our analysis thus far has dealt largely with Great Britain's foreign trade as an index of her pre-war economic status. In order to round out this treatment, a brief consideration of the development of the volume of her production, as indicated by data which are commonly regarded as accurate indexes is required. Information, illuminating as to production trends of some of the large staple industries, is contained in Chart 4, which gives curves for the consumption and production of some of the primary

CHART 5—SHOWING VARIOUS SERIES INDICATIVE OF THE PHYSICAL VOLUME OF BRITISH PRODUCTION IN EACH YEAR, 1880–1913

(Logarithmic vertical scale. Unit for Coal (Production), Pig Iron (Production and Consumption), and Steel Ingots (Production): 1,000,000 tons. Unit for Raw Cotton (Consumption) and Raw Wool (Consumption): 1,000,000 cwts.)



materials of British industry.[19] Three of the curves, for *raw cotton, raw wool* and *pig iron consumption,* and two for *pig iron* and *coal production* are carried back to the year 1880 in order to provide a long time view. A curve for *steel ingot production* is added from 1899 to 1913 to make the picture of production in the iron and steel industry more complete.

The most patent long-time conclusion to be drawn from the chart is that, on the whole, the volume of production, as revealed by these indexes, was keeping pace with the increase of population, but that it was not increasing a great deal faster. Closer observation will substantiate this inference with one exception. The long time trend of each curve from 1880, save the one for coal production, with due allowance for the numerous intermediate fluctuations, tends to be approximately parallel with that of population. The coal curve, singularly enough, displays a degree of growth somewhat greater. It will be recalled that coal exports were growing in the period before 1902 with considerable rapidity.

Taking a shorter view of the picture

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[19] This data has been taken from the Board of Trade, *British and Foreign Trade and Industrial Conditions, op. cit.,* pp. 439–47 and the *Abstract of Labor Statistics,* 1914–16 (Cd. 7733), pp. vi–vii.

from 1900 to 1913, a more detailed analysis is required because of the importance of this period in laying the foundation for the post-war protectionist edifice. All of the curves show the effect of dull trade years existing through 1903. Thereafter, all of them, save the two representing pig iron consumption and production, appear to respond with considerable vitality, showing an upward tendency greater than that shown by the line indicating population growth. In percentage terms, they increased more than twice as fast as population for coal produced and wool consumed, about three times as much for cotton consumed, and over four times as much for steel ingots produced. The increase in the production of steel ingots, however, was offset by the sluggish nature of the pig iron production and consumption. Nevertheless, in a situation containing generally such a growing volume of production, it is not difficult to understand why the protective program of the Conservative Party failed to win greater support in the years just prior to the War.

THE STATUS OF THE WORKER'S INCOME

Before terminating our statistical observations of pre-war Britain, it is interesting to note the drift of the worker's status. This is best revealed by indexes of his income.[20] According to the Board of Trade index of money wages in the principal trades (the base year being 1900) wages rose from 83 in 1880 to 100 in 1900. In addition, the Board of Trade's index of the working man's cost of living in the large cities fell from 122 in 1880 to 100 in 1900. In the case of both indexes, the movement was slowest during the last ten years, indicating a reaction from increasing resistance being encountered by British trade. Despite this slowing up, it is quite evident that very real gains were made in the working man's standard of living. The decrease of pauperism in this period is indicative of the same thing, as is also the increase in savings deposits of over two and one-half times from 1880 to 1900.[21]

These gains of the worker did not continue from 1900 to 1913. For example, the index of money wages averaged for the period but 99, and the highest figure was 105, reached in 1913. While the index of the working man's cost of living is not for this period, two other available indexes may be used as suggestive of this. The Board of Trade index of wholesale prices, for instance, after falling to 97 in 1903, rose in the subsequent years to 117 in 1913. The index of retail food prices in London, moreover, rose steadily to 115 in 1913. It is reasonable to suppose that retail costs in general followed somewhat the course of wholesale prices and London retail food prices. Such being the case, with money wages remaining sluggish as they did, the working man plainly was losing some of the gains of the previous period. Moreover, the recovery of wages was being hampered by a large percentage of unemployed in many years. Savings deposits increased 14 per cent,[22] nevertheless, and pauperism decreased 17 per cent.[23] On the whole, the working man's position was not precarious, although it was not all that could be asked.

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[20] Board of Trade, *British and Foreign Trade and Industrial Conditions*, *op. cit.*, pp. 259–60. The index of money wages is an unweighted mean of the index numbers of wages in a group of the most important trades. For the index of the cost of living, see *ibid.*, 1904 (Cd. 2337), pp. 31–3. This is a weighted mean of the index numbers for food, rent, clothing, fuel and lighting, the principal items entering into the working man's budget.

[21] *Ibid.*, 1903 (Cd. 1761), pp. 470–1 and *ibid.*, 1904 (Cd. 2337), p. 197.

[22] Board of Trade, *Abstract of Labor Statistics*, *op. cit.*, pp. 326–7.

[23] *Ibid.*, p. 330.

A BRITISH ANALYSIS OF THE WEAKNESSES IN PRE-WAR TRADE

There are other elements in the situation besides the facts which are revealed by statistical data which demand our study. These are reviewed by the analysis of the Committee on Commercial and Industrial Policy after the War, with regard to pre-war trade.[24] The analysis is significant because it reveals what an important and representative British group considered to be the weakness of the pre-war situation. The portion of the report in which we are interested reads:

> Whilst British industry, on the whole, had shown in the preceding decade great vitality and power of extension, its strength and development had been mainly in a certain number of long established manufactures of which coal, cotton and the textile trades generally, shipbuilding and some branches of the engineering trades (such as textile machinery) are the most conspicuous examples. One important exception must be made on this general proposition; the iron and steel trades have made comparatively little progress. . . . In the rise and expansion of the more modern branches of production, the United Kingdom had taken a very limited share; as is evidenced by our relative weakness in respect to the electrical, chemical and chemico-metallurgical industries; and it is admitted that in a number of smaller trades, foreign manufactures have shown greater enterprise and originality.

In short, British industry had failed to acquire diversity in modern development and had been content to progress along staple lines directed by the sheer force of momentum. As a result of this, distinct dangers threatened British industry as a whole, according to the report: *i.e.*, (a) certain branches of production, of great importance as a basis for other manufactures, had come to be entirely under foreign control; and (b) foreign manufactures had secured a strong or even dominant position in numerous other branches of industry, and thus could successfully prevent the establishment of British competition.[25] Moreover, the concentration of her industrial risks in a limited number of staple lines increased susceptibility to trade fluctuations. British ingenuity, the inference is, had failed to fulfill its obligations and had been tactically outwitted in international economic competition.

SUMMARY

In order to relieve any confusion which our detailed analysis may have caused, let us briefly recapitulate. A rapid survey of British foreign trade before 1912 showed that for all British exports there was a retardation after 1870, save for coal and machinery which continued their rapid growth (see Chart 1). This growth and the trend of exports to protected and unprotected markets was the cause of apprehension in some quarters. Imports, on the other hand, showed a constant tendency to increase. Since they contained a growing proportion of manufactured goods, increasing competition must have been felt in the British home market, even allowing for manufactured imports not produced by the British themselves.

Foreign trade after 1900 suffered a few years of hesitant activity but in the last half of the pre-war period exhibited an encouraging capacity for expansion. Of the staple industries whose exports were examined more closely, the woolen industries made the poorest showing. Our analysis of the shifts occurring in British markets after 1900 indicated that, in protected markets, British manufactured exports were handicapped by tariff barriers and the competing industrial technique developing behind them. Other foreign markets were erratic, while Empire markets alone were consistent absorbers of British products.

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[24] *Final Report* 1918 (Cmd. 9035), p. 21.

[25] *Ibid.* The (a) group included such industries as synthetic dyes, spelter, tungsten, magnetos, optical and chemical glass, hosiery, needles and others named in the Committee's *Interim Report on Certain Essential Industries*, 1918 (Cmd. 9032). The (b) group included such industries as glassware, brooms, and brushes, bentwood furniture and others named in *Report* of Sub-Committee to Advisory Committee to the Board of Trade, 1916 (Cd. 8181).

In pursuit of the question of growing Empire inter-dependence as a means of illuminating the preference movement, we found Great Britain becoming increasingly dependent on the Empire for her food supply. On the other hand, the Empire was relying increasingly on other markets for export outlets and also for import sources, making increased competition for the British manufacturer. On the whole, our analysis of Imperial trade from 1900 to 1914 suggested the conclusion that forces from this source were tending to become favorable to a preferential tariff.

A review of production indexes revealed that production was keeping ahead of population in the long run. A spurt was evidenced after the relaxation at the beginning of the century which may account for the failure of the Conservative Party's protectionist program to arouse a more general interest. The worker's status at the end of the period was not perilous. As a consumer his interest lay definitely in free imports.

Finally, we have noted the self-acknowledged lethargy of British enterprise, and the failure to take full advantage of the opportunities created by the expansion of human wants. An unwillingness to sacrifice a large present income to the launching of new industries, seriously limited the diversity of her enterprise. It also dangerously concentrated the risks, weakening the fulcrum upon which a highly intensified industrial civilization rested. This aspect of the problem grows more acute when we recall that two of the great staple industries (coal and iron) were based upon resources whose exhaustion could be foreseen. Quite clearly, we are fully justified in asserting that economic forces were at work which might lead to the demand for a protectionist policy, and that these forces were ripening for a climax. The War stimulated the forces at work and hastened the climax.

CHAPTER V

POST-WAR INDUSTRY AND TRADE AND THE MOVEMENT TOWARD TARIFF PROTECTION

THE changes and shifts brought about by the unusual circumstances of the war period were felt mainly in the succeeding era of readjustment. The dependence of the British economic status upon world trade, with the latter greatly altered and at the point of exhaustion from the long conflict, has conditioned her recovery. Obviously, the influences at work have been inextricably complex and ramifying. It is our purpose in this chapter to treat some of the underlying forces tending to mould the direction of Great Britain's recent economic evolution. Before undertaking that, however, it will be necessary to give a general impression as to the nature of her trade and industrial conditions up through 1927. Because of the recent availability of abundant statistical indexes, it will be possible to make our analysis more descriptive of the whole situation. Our procedure, therefore, differs radically from that in the previous chapter. It is believed that such a treatment will make possible a clearer understanding of the post-war protectionist developments.

GREAT BRITAIN IN AN INDUSTRIAL DILEMMA

Upon release from war-time pursuits in 1918, British industry set about with astonishing vigor to fill the gaps and omissions created by her long military concentration. Her problem of reconstruction was different from that of her Continental Allies, because she had suffered no physical destruction. The task of readjusting and rehabilitating industry to peace-time occupation was the main one facing her. This was not to be accomplished with the ease one might expect, though the British themselves were deluded into thinking so as the world frantically set about replenishing its depleted stocks. Business men will recall the nature of the times. A seller's market existed, and for the British manufacturers this brought its worries. Raw material sources might easily fail. Hence, British aims were immediately to control sources of supplies, and to maintain as close relations as possible with the dominions in order to share adequately in those supplies under their control.

As a consequence, her whole commercial policy became imbued with an imperial spirit. The attitude she assumed at the Peace Conference, refusing to coöperate with France in the matter of raw materials, was full evidence of this, in the opinion of the eminent French critic, M. André Siegfried.[1] The same critic asserts that it is revealed further by the British control over the export price of coal in the early period following the Armistice, and the 1919 grant of Imperial preference. Under no necessity to cultivate markets during this period of hectic international selling, the outlook of British leaders was distorted by the seemingly fundamental importance of securing raw materials. The primary need of realizing Great Britain's ultimate economic dependence on the export markets of the world was obscured temporarily in their minds.

Circumstances operated to prevent such a situation from remaining long the case. Much of Great Britain's exaggerated activity arose out of the artificial stimulation of continuous world-wide inflation. The inevitable bursting of the bubble brought the British and others to their economic senses. Industry and trade dropped rapidly into the deepest depression. Export trade melted away, and unemployment rose to unprecedented heights. The failure of Great Britain's Continental and overseas customers to absorb her products, and the difficulties encountered due to depreciating exchanges urgently demanded a reconsideration of policy.

Furthermore, Great Britain was having her own struggles with currency in restoring the gold standard according to the stringent recommendations of the Cunliffe Commission. The resulting disparity between external and internal prices unquestionably affected export trade.[2] Depression relentlessly persisted. Protective measures offered doubtful relief in the opinion of leaders and the people. Hence, free trade doctrines, though mere shadows of their former selves, were invoked again as the commonly accepted standard of the British economic system. But they did not remain in the ascendancy long; continued dullness in all branches of trade and industrial activity occasioned further recourse to protective devices, the story of which our third chapter related.

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[1] Siegfried, *op. cit.*, pp. 19–24.

[2] *Ibid.*, pp. 29–43. See also, [Keynes, J. M., *The Economic Consequences of Sterling Parity* (New York, Harcourt-Brace, 1925).

INDEXES OF POST-WAR ECONOMIC CONDITIONS

A clear view of the extensive nature of Great Britain's depression is gained from tracing the general movement of business over the post-war period. Four indexes are available which are declared by authorities to illuminate her recent economic trend. They include an index of prices for twenty industrial stocks, the Board of Trade's index of material prices, an index of exports of British manufacturers, and a short money index.[3] All of the indexes are corrected for seasonal variation and are relative to the 1913 average. They have been plotted on Chart 6, which the reader should note carefully following our description.

We readily see that trade followed a steep upward course after the War, reaching a peak about the middle of 1920. This was a time of frenzied activity; all types of businesses and all forms of industry were under tremendous pressure to produce. Production figures for the iron and steel and shipbuilding industries were unusually high. Unemployment figures fell to a lower level than at any period during the years from 1900 to 1914 (2.3 per cent in 1920 and 1.6 per cent in the first nine months of 1921). In addition, the per cent of pauperism was low. Prices, the cost of living and wages, on the other hand, rose to almost untold heights. The index of the cost of living, for example, reached a high point of 276 in October, 1920, and wages 277 in January, 1921. Beginning in the last quarter of 1920, there occurred a precipitate decline into the depths of depression, accentuated by the coal strike of 1921. There British trade and industry has remained to date.

The situation existing throughout 1922 appeared practically hopeless, in spite of a slight improvement toward the end of the year. Never in her long history had the United Kingdom been faced with a more critical trade crisis. The iron and steel industries did not recover, nor did engineering, cotton, woolens and worsteds. The distressing thing was that they did not reveal any signs of such a likelihood. Exports fell off; shipping was unprofitable; shipbuilding was at a standstill; and railway traffic in general merchandise, a fairly good index of domestic trade, was only 80 per cent of its 1913 figure and smaller still when compared with the boom year of 1920. Unemployment reached the astoundingly high level of 23.1 per cent in June, 1921, exclusive of coal miners on strike. Throughout 1922 it remained high, ranging from 14 to 17 per cent.[4]

A PERIOD OF FALTERING TRADE, 1923 TO 1927[5]

The year 1923 opened, as anticipated, with a degree of recovery and a new spirit of hopefulness. All indexes

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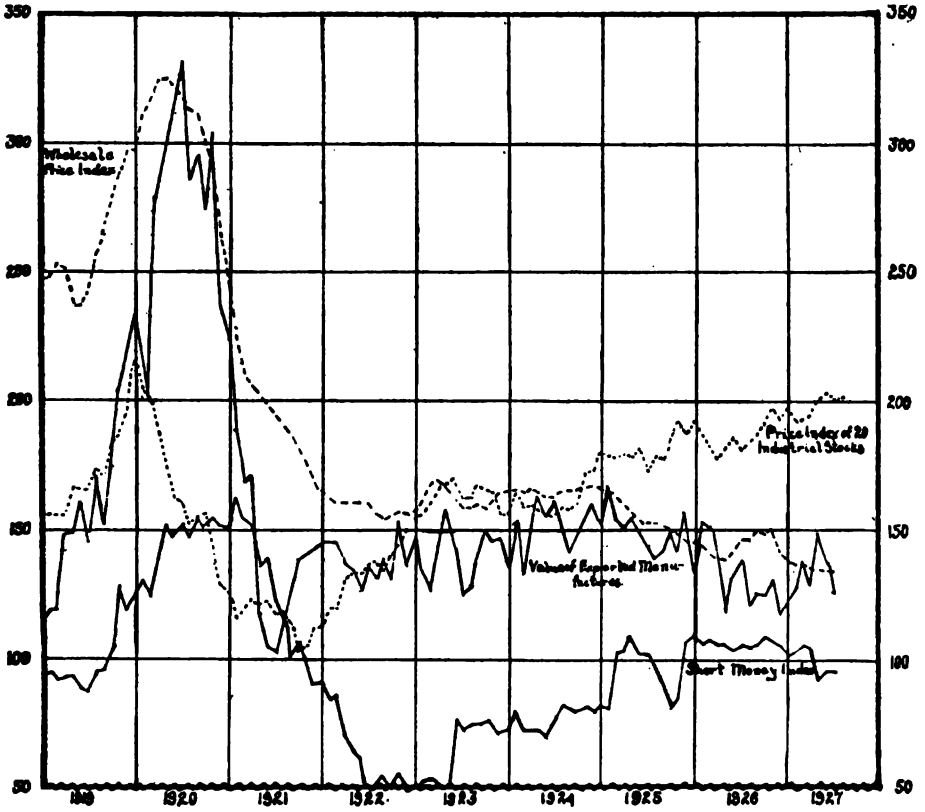
[3] Bowley, A. L. (and others), "An Index of British Economic Conditions, 1919–1922," *Review of Economic Statistics*, Vol. IV, p. 144, and the accompanying statistics, pp. 152–5. See also various letters of the *Harvard Economic Service*, 1923 to date. Chart 6 has been adapted from these sources. Prior to 1923, the Board of Trade index of wholesale prices, instead of material prices, is used.

[4] This index is said by some, however, to exaggerate the degree of depression.

[5] In this connection see the various letters of the *Harvard Economic Service* on British economic

CHART 6—SHOWING FOUR IMPORTANT INDEXES OF RECENT BRITISH ECONOMIC CONDITIONS, MONTHLY, 1919–27

(The data are relative to the year 1913 as the base. After 1923, the Wholesale Price Index is confined to the wholesale prices of materials alone)



encouragingly revealed healthy activity. Reaction followed in the second quarter, however, due to the failure of the export markets to absorb products as expected, the result of unsatisfactory conditions on the continent. In short, for the remainder of the year, the situation was about as follows: shipbuilding, the cotton and worsted industries were in deep depression; iron and steel exports were holding their own; imports were increasing; domestic trade, as shown by general merchandise railway traffic was holding up; and the unemployment situation was improved, although the percentage out of work was still over twice the figure which would have been alarming before the War.

Commodity prices which had remained relatively stable during the years 1922 and 1923 rose somewhat in 1924, falling again in 1925 and 1926, with a recovery in the latter months of this year, but a further fall in the first seven months of 1927. The general

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conditions, from 1923 to date. See also the various indexes of British conditions published in the "Statistical Record," *Review of Economic Statistics*, Vols. VI, VII and VIII. These indexes, whose original source is the London and Cambridge Economic Service, are used as the basis of this analysis.

level of money wages which had decreased in the first two of these years, rose again in 1924, remaining stable around 180 the next two years. The cost of living, on the other hand, faltering after its previous decline, rose again in the last of 1923 and first of 1924. After some fluctuation in that year, a further decline occurred in 1925 and 1926.

In 1924, improvements occurred in the textile industries, but otherwise conditions remained the same. The return of the Conservatives to power is said to have had a steadying influence on business. Optimism increased, as did also its material manifestation, imports of raw materials, presaging greater production and exports. Hopes failed to be realized. A return to the gold standard in May, 1925, accentuated a number of problems due to the disparity between import and export prices. A pronounced recession followed in the leading export industries; unemployment increased, a menacing coal strike was threatened, and averted only by government action. In addition, the unfavorable status of industry on the continent continued to affect adversely Great Britain's general commercial position.

The year 1926 was significant largely for labor conflict and declining industry. The failure of the Coal Commission's report to afford a practical basis for compromise led not only to a coal but a general strike. While the general strike lasted only a few days, the coal strike continued until the miners were forced back to work without a satisfactory settlement. Widespread industrial repercussions inevitably accompanied this strife. Production was curtailed in all major fields, intensifying an acute unemployment crisis. The value of exported manufactures fell to the lowest figure since 1921. This decline was most pronounced in such exporting industries as iron and steel, textile machinery, china and earthenware, cotton yarn and piece goods. Moreover, the financial situation growing out of such a severe depression was extremely serious. Unsettled conditions in the overseas markets further complicated matters. The year 1926 came to a close with industry and trade in as dangerous a position as ever in their history.

Despite these facts, optimism was rife in December that the year 1927 would see a rapid and general recovery. As is seen by the 1927 curves on Chart 6, some recovery was in evidence, especially in the late spring months. A pronounced decrease in unemployment in the iron and steel industry, engineering, shipbuilding and commercial trades was evidenced in June, although in the coal areas it continued large due to the failure of export markets. The physical volume of production reached its highest level since 1920.

POST-WAR BRITISH AND WORLD TRADE

Since British trade is so completely dependent on overseas markets, the continued depression in the United Kingdom, as we have suggested, was in a measure a result of conditions beyond her control. Hence, certain questions arise; for example, what has been the general trend of world and British trade since the War? How do the present magnitudes compare with the magnitudes in the years just preceding the War? Is the share of Great Britain's trade an increasing or decreasing share in the aggregate trade of the world?

Replies to these questions cannot be made, of course, with close accuracy. Reliable approximate answers, nevertheless, may be advanced. League of Nations and British experts compute that in 1923, in terms of nominal gold value, the world's trade was 31 per cent greater than in 1913,[6] 46 per cent in 1924 and 63 per cent in 1925.[7] Splitting this world trade percentage up into imports and exports, imports were in 1923, 30 per cent higher than in 1913, 44 per cent in 1924 and 62 per cent in 1925, while exports were 31, 48 and 64 per cent respectively. For the same period, plus the year 1926, the nominal gold value of British imports increased 45 per cent in 1923 over 1913, 56 per cent in 1924, 77 per cent in 1925 and 88 per cent in 1926. Exports, on the other hand, showed an increase over 1913 of 41, 38, 46 and 24 per cent respectively. When we consider these increases in British trade as percentages of the increases in world trade, interesting facts are revealed. British imports as a percentage of total world imports, to quote the precise League of Nations figures, increased from 16.48 per cent in 1913, to 17.89 per cent in 1924 and 17.79 per cent in 1925. British exports as a percentage of the total world exports, on the other hand, actually decreased from 13.93 per cent in 1913 to 13.01 per cent in 1924 and 12.43 per cent in 1925.[8] Naturally with the curtailment of British export trade in 1926, which we have noted previously, a further decrease in the percentage of British export world trade would appear.

It will be seen at once that little comfort can be derived by the British economist from a study of world trade figures. When it is recalled that, in the same period, world prices of commodities measured in nominal gold values were variously from 50 to 60 per cent higher than in 1913, the situation becomes serious.[9] World trade, reduced in terms of 1913 prices, was in 1923 only 85 per cent of the 1913 figure, in 1924, 98 per cent and in 1925, 104 per cent.[10] Possibly if 1926 figures were available a further slight gain would be shown. This means that in actual volume of world trade there has been but a small gain and that only in the most recent years. It means further that the increased percentages of British and world trade in terms of gold value really conceals a diminution in the total volume of British trade. When adjusted to 1913 values we find that British imports were, in 1923, 86 per cent of their 1913 figure, 90 per cent in 1924, 106 per cent in 1925, and 127 per cent in 1926. British exports, on the other hand, were respectively 81, 77, 89 and 83 per cent of their 1913 volume.[11] Stated in terms of the League of Nations index of quantum of trade, British imports were in 1923, 93 per cent of their 1913 quantity, in 1924, 104 per cent and in 1925, 108 per cent, while exports for each of the respective years were 75 and 76 per cent in terms of 1913 quantities.[12] This shift in volume may be seen more clearly by the accompanying chart, Chart 7, adapted from the *Board of Trade Journal*, which shows imports and exports for 1925 and 1926 compared with the averages for 1909–13, the values throughout being adjusted by the Board of Trade index number on the base of the average prices of 1924.[13]

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[6] The 1923 figures are from the Committee on Industry and Trade, *Survey of Overseas Markets*, p. 667.

[7] The 1924 and 1925 figures have been taken from the League of Nations, *Memorandum on the Balance of Payments and Foreign Trade Balances, 1911–25* (Geneva, 1926), pp. 131–5.

[8] *Ibid.*, pp. 132–3.

[9] Computed from League of Nations figures, *Ibid.*, p. 135.

[10] Committee on Industry and Trade, *op. cit.*, pp. 3–4.

[11] Adjusted prior to 1926 by the Federal Reserve Board indexes of British import and export prices and in 1926 by the Board of Trade all-commodity price index.

[12] League of Nations, *op. cit.*, p. 148. These figures contain approximate adjustments for the Irish Free State.

[13] "Imports and Exports in 1925 and 1926," *Board of Trade Journal*, Vol. CXVIII, pp. 94–5.

THE DECLINE OF PURCHASING POWER IN OVERSEAS MARKETS

There are doubtless many reasons which may be assigned for the falling off of British trade in this post-war period. Our previous analysis has suggested some. Among the most pertinent of these is the decline of purchasing power in nearly all countries.[14] This has been due mainly to the general derangement of the economic mechanism of the world, and the widespread political alterations resulting from the Versailles Treaty. The influence of impaired consumption has been present in nearly every country in greater or less degree. Hence, its effects have been universal. Such an extensive decline of demand inevitably affected Great Britain, dependent as she is upon her export trade.

The decline of purchasing power has been perceptibly greater in the countries of central and eastern Europe, and in the near and far east, than elsewhere. Political conditions have dislocated the markets of India, China, and Russia, while others have been temporarily destitute because of financial disruption and a chaotic condition of currency and exchange. In addition, the mere fact of generally and rapidly declining prices has tended to discourage purchases for more than immediate needs. The general recovery of price and exchange stability in the last few years, of course, has tended to make this a less important element. Furthermore, it has been accompanied by some recovery in purchasing power, especially in central Europe. Nevertheless, on the whole, a curtailed purchasing power will doubtless characterize overseas markets for some time to come.

THE GROWTH OF LOCAL MANUFACTURE AND ITS EFFECT UPON BRITISH TRADE

A tendency always exists for the development of local manufacture to satisfy needs formerly supplied by imports.[15] Ordinarily, this process of substitution takes place slowly in a normal way and allows time for the necessary adjustments in the flow of trade. The World War had the effect of stimulating such development in many countries. Moreover, the War led to the establishment of industries which were essential to the demands of military activity. While many of these naturally vanished with demobilization, others continued to exist either through a natural capacity or some kind of protection obtained on the basis of national security, or general grounds of commercial policy.

Among the principal markets in which local manufactures were growing up were Canada, Australia, India, Brazil, Argentina and Chile. The movement had been given an extra stimulus by the growth of intense nationalism and was fostered by various means of governmental action. This growth of local manufactures may have reached a state of overdevelopment, and will probably experience a contraction in the future; but for the time being, it has had a seriously restrictive effect upon established trade in general and British trade in particular.

The situation just escapes being hopeless from the British point of view, because of two offsetting considerations. The first is that new manufactures are largely concerned with simpler and coarser classes of goods, the field of international trade being left to engage itself in the manufacture of quality goods. There has been a tendency for British exports to consist

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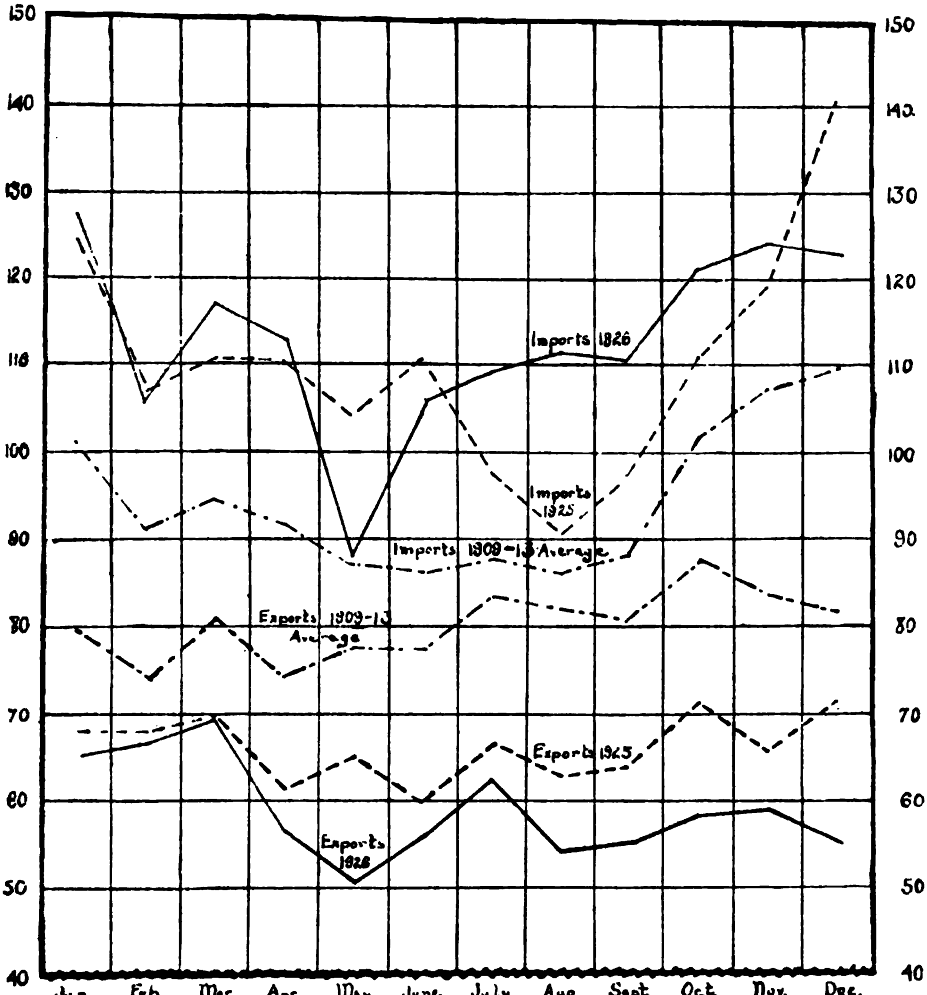
[14] Committee on Industry and Trade, *op. cit.*, p. 4

[15] Adapted from *ibid.*, pp. 9–13.

CHART 7—SHOWING BRITISH NET IMPORTS AND EXPORTS IN 1925 AND 1926 COMPARED WITH THE AVERAGES FOR 1909–13

(Values adjusted in accordance with 1924 average prices. Allowance has been made in the 1909–13 curves for the effects of the separation of the Irish Free State. This Chart has been adapted from the *Board of Trade Journal*)



more and more of quality goods. Thus, this movement in international trade may be beneficial to British industry because it operates to offset disadvantages in comparative costs. It also may mean that in the future the larger share of international trade will be captured by exporting countries "most capable of adapting their production to special qualities of goods." Such adaptability was not clearly evidenced in British pre-war exports.[16]

The second compensation is more elusive but may be just as important in the long run. It is the fact that new industries create new wants for plant and materials, and also make additional purchasing power for those whom they employ. For example, the increase of wealth in the United States accompanying its industrialization has given rise to a "luxury demand almost irrespective of price" which has benefited British products. It was accompanied by a slowing down of American food exports, which, in turn, has stimulated their increase from other areas and created a demand for British products there. It is clear from the foregoing illustration that this consideration is complex and difficult to trace. The basic condition in its analysis is that the capacity of markets to absorb is limited, in any case, by the outlets available for their exports; and it must not be forgotten that all such shifts in international trade are accompanied by temporary loss and suffering. The diminishing margin of profit which tends to characterize modern industry makes it especially susceptible to such shifts.

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[16] See above, p. 74.

THE GROWTH OF FOREIGN COMMODITY PROTECTION AND BRITISH TRADE

The growth of various sorts of governmental protection has been a concomitant to the development of local industry. Such a growth has been accomplished principally in four ways: (1) by means of customs tariffs; (2) by means of prohibitions or restrictions, with or without a system of licenses; (3) by means of special privileges, concessions, or subsidies to local industries; and (4) by means of state control and monopoly.[17] Of these, tariff measures are easily the most important. The question arises as to the extent to which British trade has been limited by their growth from the period before the War. British authorities have made a study of the problem (1924), and reached the conclusion that:[18]

> . . . the average increase of tariffs on articles selected as representative, *i.e.*, the increase of charge expressed in terms of sterling per unit of product (not per unit of value), has not materially exceeded the average increase in value of the articles exported.

This is the same thing as saying that, up to the time of the study, the average *ad valorem* incidence of tariffs has not materially increased. It suggests that tariffs have not been an important factor in retarding the recovery of British trade. The same level of tariffs being retained and a fall occurring in prices, they inevitably have a greater effect, because the *ad valorem* incidence of specific duties is automatically raised. Hence, where price declines have been significant tariffs have played an increasingly important part in restricting trade. That such has really been the case may account for the prominence of tariff discussions in the recent meetings of the League of Nations' Economic Conference, the International Chamber of Commerce and the Inter-parliamentary Congress. It is further suggested by the distribution of British trade to ten of the principal protected countries whose tariffs were closely analyzed in the study referred to, this group taking 36.6 per cent of her exports in 1913, 37.2 per cent in 1923, 33.9 per cent in 1924, 34.9 per cent in 1925, and 29.8 in 1926.[19]

Concerning other forms of trade restriction for the purpose of protection, the use of prohibitions and restraints has been especially prevalent since the war. In some countries, particularly those in central Europe, they have become a predominant feature. After some experience with these measures and their effects, there has appeared a tendency to reduce them to a minimum. Special concessions, privileges and subsidies have been granted to various industries, most important of which has been shipping. This action among foreign countries, the United States, for example, has been very injurious to British shipping. The shipping interests have also been the principal ones affected by state control or monopoly. The number of countries operating or controlling commercial shipping has increased to include the United States, Belgium, Roumania and Soviet Russia.

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[17] Adapted from the Committee on Industry and Trade, *op. cit.*, pp. 13–21.

[18] *Ibid.*, p. 14.

[19] This group included the United States, Germany, Argentina, France, Japan, Brazil, Belgium, Italy, Spain and Sweden. See *ibid.*, pp. 545 and 646–8. Also the various articles in the *Board of Trade Journal* on the annual distribution of British foreign trade.

COMPETITION BETWEEN BRITISH EXPORTS AND THE EXPORTS OF OTHER COUNTRIES IN OVERSEAS MARKETS

An opinion commonly expressed by British trade leaders, especially during the period of the War, was that their exports into overseas markets were being widely displaced by imports from other sources.[20] This sentiment was, in part, a reflection of the intensity of competition immediately preceding the War. It was also in part an expression of fear concerning Britain's chances of regaining her foreign markets. Apparently, there was no evidence of such an event occurring.[21] Some competitors have improved their position or have retained it unimpaired; while others have suffered and are in a greatly weakened condition. Germany, for example, practically disappeared from the markets, and has had difficulty regaining her place, although she has made some strides in that direction. Reparation payments may stimulate her recovery. France, on the other hand, has become an important industrial country because of the acquisition of mineral wealth as a result of the Treaty. The United States is also in a strong position with regard to the trade of the world; while Belgium, an important trading country before the War, has not entirely recovered her position. Among other competitors, Italy has acquired strength in certain textiles, and Japan, also strong in textile production, retains a formidable place in still other lines.

Prominent among the influences aiding some countries to improve their situation has been depreciated currencies. Another which has handicapped certain countries in their recovery has been the shortage of capital. These factors appear to be of a transitory nature but may have effects which will persist far into the future. British trade does not seem to have suffered ill treatment in the markets of the world, and, in general, stands on about equal footing with other countries. She enjoys distinct tariff advantages in trade with the dominions, and a real advantage accrues to her from France's minimum tariff schedule which is not enjoyed by any other important commercial nation.

THE GROWTH OF BRITISH PREFERENCE AMONG THE DOMINIONS AND ITS VALUE TO BRITISH TRADE

It will be recalled that nearly all the self-governing dominions, except Newfoundland, granted preference prior to the War. After the War, the same group continued—indeed, increased—their preference grants. For example, in 1914, the preference granted by the dominions was on the average higher than their general tariffs by about 4 per cent *ad valorem*. By 1925, this preferential advantage had been increased to 9 per cent *ad valorem.*[22] The increases, *ad valorem*, for the various dominions, have been as follows: 8 per cent in the case of Australia; 8½ per cent in the case of New Zealand; 2½ per cent in the case of Canada; while the level of preference in South Africa has remained relatively unchanged, although she has removed preferences in lines where Great Britain has led the competitive field. With regard to India, no preference could be granted by her before the War because of the dominating influence of the British in her governmental administration. During the War her government was reorganized, leaving her with a large degree of fiscal independence. Since that time she has taken several protectionist measures and embodied them in tariff enactments. It is the hope of many of the British that India will shortly arrange to grant such preferences as are consistent with her tariff policy.[23]

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[20] See, for example, Hewins, *op. cit.*, Chapter IX.

[21] Adapted from the Committee on Industry and Trade, *op. cit.*, pp. 21-3.

It is extremely difficult to obtain any measure of the benefit of preference to British trade. The influence of coöperative effort to execute the War effected closer economic relations in the Empire and should certainly be stressed. All effort was made at that time to divert the greatest possible proportion of colonial and dominion exports of food and raw materials into the United Kingdom. In some cases, official purchases by the British Government were of paramount importance in directing this flow. The British themselves are quite convinced that a beneficial effect has accrued from preference. One statement from an authoritative source has even asserted that there is left "no room for doubt that the advantage has been substantial."[24]

In confirmation of this, the percentage of British exports taken by various parts of the Empire rose as follows from the annual average for the ten-year period from 1904 to 1913.[25]

	Per Cent
Annual average, 1904–13	34.8
1922	37.5
1923	37.2
1924	38.5
1925	39.2
1926	44.8
1927 (first quarter)	43.02

This increase in exports to the Empire has been largest with the dominions, and especially with Australia, which received 9.9 per cent of the total British exports in 1926 and the first quarter of 1927. A slight increase also occurred in the percentage of exports to New Zealand and South Africa, but not to Canada. Exports to other possessions increased slightly from 6.3 per cent in 1913 to 8 per cent in 1925, 8.6 per cent in 1926 and 9 per cent for the first quarter of 1927. Those to India, on the other hand, fell off slightly from 13.4 per cent in 1913 to 11.8 per cent in 1925, recovering to 13.3 per cent in 1926 and 12.3 per cent for the first quarter of 1927.

Imports from the dominions and possessions also increased, being 24.9 per cent in 1913, 27 per cent in 1924, 29.6 per cent in 1925, 27.3 per cent in 1926 and 26.8 per cent in the first quarter of 1927. No outstanding shift in the percentage taken from any single dominion is observable, although most of the increase is accounted for by the imports from Canada, Australia and New Zealand. From India, imports like exports have decreased from 6.3 per cent in 1913 to 4.8 per cent in 1926 and 5.04 per cent for the first quarter of 1927. This growth in trade with Empire markets, coincident with the growth in preferential allowances, is the basis for the conclusion regarding the benefits of preference, a conclusion which must be carefully qualified.[26]

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[22] Committee on Industry and Trade, *op. cit.*, p. 24. In addition, preferences are now granted by a number of dependent colonies, ranging from 3% to 25% *ad valorem*. See pp. 551–3.

[23] *Williams, L. F. R., India in 1924–25* (Gvmt. of India Central Pub. Branch, Calcutta, 1925), pp. 166–73.

[24] Committee on Industry and Trade, *op. cit.*, p. 24.

[25] These figures exclude exports to the Irish Free State. See articles on the distribution of trade published in various issues of the *Board of Trade Journal*. In this connection, it should be recalled that the actual volume of British export trade in the post-war years has been very much lower than the 1913 volume. See above, pp. 83–4.

Further qualification is needed, too, when we consider the extent to which the United Kingdom shares in the total imports and exports of the self-governing colonies.[27] In every case, from 1913 to 1925, there has been a decrease ranging from 4 to 8 per cent in the percentage of imports received from the United Kingdom. Save in the case of New Zealand, there has likewise been a decrease in the percentage of dominion exports sent to the mother country, amounting in the case of South Africa to 32.5 per cent. It must not be forgotten, however, that the volume of trade carried on by each self-governing colony with the United Kingdom remains a significant proportion of their total trade. Doubtless, rather than admit the failure of preference to benefit them, the dominions would contend its application had been insufficiently extensive. It is from the point of view of Great Britain, however, that a justification of post-war preference must be sought. Certainly the admission of the importance of preference by the Committee on Industry and Trade lends the weight of official sanction to the protectionist argument that the policy of free imports no longer meets the exigencies of British trade.

SUMMARY

Having described generally the depression obtaining in British industry and trade up to the present time, we have seen on close analysis that the post-war period has witnessed a very considerable shrinkage in her trade volume.[28] Four underlying influences which have been assigned special importance in causing this shrinkage were reviewed carefully: first, the decline of purchasing power in overseas markets; second, the growth of local manufactures; third, the growth of foreign commodity protection; and fourth, the state of competition in the export markets. Finally, we noted the growth of preference among the colonies and the statement of the Committee on Industry and Trade concerning the value of preference, and examined the available trade data which might support such a view. Considerable qualification appeared to be necessary. Before concluding finally upon Great Britain's post-war industry and trade and the movement toward protection, let us regard it in relation to our previous development, passing such judgments as seem warranted in the light of our entire treatment.

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[26] Professor Henry Clay points out, in this connection, that the real explanation of increased exports to Australia and New Zealand lies in the recent outburst of prosperity in these dominions, and also in the fact that these markets have been the recipients of large loans from London since the War. Professor Clay believes that there can be no effective preferential scheme without a general system of protection, which does not suit the needs of the English economic system. See his article, "Imperial Economic Relations," *Manchester Guardian Commercial*, Vol. XIII, pp. 445–6.

[27] The figures which have been used in this connection are found in the League of Nations, *op. cit.*, pp. 158–61.

[28] A very good brief presentation of the economic problems confronting Great Britain at the present time is contained in a statement submitted to the recent International Economic Conference (Geneva, May, 1927) by the British members of the Conference. See the documents of the Conference, League of Nations, *Principal Features and Problems of the World Economic Position from the Point of View of the Different Countries*, C. E. I. 29, 1st series (Geneva, 1927), pp. 18–25.

CHAPTER VI

CONCLUSION

THAT a pronounced trend toward tariff protectionism has occurred in Great Britain in recent years has been evidenced in the historical facts here assembled. Its embryonic origins, both political and economic, have been seen to lie many years in the past. We may fairly wonder where the ultimate end may be. Is a return to simon pure free trade, for example, within the realm of possibilities? If not, will Great Britain, when faced with the international consequences of a protective system, hold out to the world as a protagonist of free trade, while within the Empire, advancing and extending a program of preferential protection?[1] Have international trade conditions so altered as to warrant the overthrow of the traditional free trade principles as the basis of her tariff system? Is it at all probable that Great Britain might erect a general protective system? Would such a change be desirable from the standpoint of her own self-interest?

These and countless other questions have doubtless arisen in the mind of the reader. No complete answer can be made to them, but we may appreciate the significance of current trends in the light of the facts which have been related. The policy of free trade, when adopted, unquestionably was an important factor in enabling Great Britain to gain an enormous advantage in world trade, other factors, of course, contributing. Propitious circumstances, in other words, during the period from 1851 to 1901, permitted an extraordinary development of industry, trade and commerce.

Rising standards of living were witnessed on every side. Population, confirming the Malthusian conclusions, rose from 27.4 millions in 1851 to 41.5 millions in 1901, an increase of 51 per cent, tending to fill the gaps opened by rising standards. The importance of this is appreciated more thoroughly when we recall the limited area of the British Isles. In other words, the increased concentration of population which accompanied Great Britain's economic expansion, meant a highly compact industrial civilization largely dependent upon foreign sources of supply for its principal foods and raw materials. The maintenance of existing standards, or slightly rising standards of living, for such an increasing population, thus was dependent upon the growth of trade at an equal or a slightly faster rate. On the other hand, anything which might interfere with or interrupt the required circular flow and growth of commerce would be attended with disastrous consequences.

The last century saw this development go on almost unhindered up to 1873, with a slowing down after that year. The continuity of its increase was maintained, however, through the fourteen years following 1900. Population growth continued to persevere, likewise, increasing 9 per cent more from 1901 to 1911. In 1914, the dreaded interruption occurred, despite which population increased 4 per cent more before 1921. What has happened since, the far-reaching nature of British depression with its extended unemployment, has been reviewed. Hardship and distress have prevailed necessarily among many classes. Although the average level of "real" wages for full time work was not substantially different in 1925 from the pre-war level, if allowance is made for the widespread unemployment and short time employment prevailing in many industries, the average level of "real" weekly earnings has been much lower than it was immediately before the War.[2] Reduced incomes in many groups, therefore, have resulted in a measurable lowering of their standards of living.

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[1] M. André Siegfried suggests this. See his book, *op. cit.*, p. 29.

The situation, in view of the population figures, is tense. Britain, in consequence of the pressure she must feel, is obliged to do all in her power to maintain the operation of the economic system which she has built up. Things must be kept running at all costs. It is no wonder, perhaps, that her leaders have been tempted to grasp at the alternative of protection when the machine has failed to operate smoothly under free trade. Doubtless, no government could be expected to hold to the broad and enlightened reasoning of orthodox economic teaching in circumstances rife with dangers. The British leaders are forced to witness the pressure of world forces on the means of national subsistence now as never before. In short, to the political party in power charged with the responsibility of trade recovery (especially if it be already possessed of protectionist inclinations), the straight and narrow path of free trade has become a thorny road; while the various ways of protection have appeared as the paths of possible solution.

Returning to our story of free trade and protection, let us regard some of the important facts relating to the origin of the former. Historically, authorities generally agree that its adoption arose from the practical pressure of self-interest among the manufacturing classes, whose conviction of its efficacy constituted the chief basis of its support. The outburst of prosperity and the growth of trade following the application of a free import fiscal policy led to its general acceptance by the popular mind. Any question of its merits thus became superfluous. As a national policy, it acquired a traditional and sentimental aspect which tended to become ingrained as a strong popular bias.

With the first great depression (1868), there appeared to be some question of the soundness of the policy. The growth of tariff barriers abroad obstructed some of the most important outlets for British products; and the development of an industrial technique behind them increased competition. Such barriers and accompanying competition were not only becoming common with foreign countries, but increasingly frequent in the self-governing colonies. More than that, the periodic recurrence of depression in the three decades following this date stimulated an "off and on" protectionist agitation, keeping the issue thoroughly alive.

In the last fifteen years of the nineteenth century, there occurred the first meetings of colonial and British representatives in conference, bringing with them the initial suggestions of an Imperial tariff system, based on the principle of reciprocal preferential treatment. Coincident with these Colonial Conferences was the growth of a new popular interest in the Empire, and the turn of the century was marked by the awakening of colonial concern.

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[2] Committee on Industry and Trade, *Survey of Industrial Relations*, 1926, pp. 96–8.

The idea of an Imperial tariff system, based upon the principle of preference, expanded into a movement of large proportions, and made propitious such a campaign as was carried on by Mr. Joseph Chamberlain from 1902 to 1906. Among the events of practical significance which aroused much thoughtful consideration of the problem at that period were: (1) the increasing difficulty of surmounting foreign tariff barriers, the expansion of competition, and the frequency of trade depressions, which we pointed out above; (2) the willingness and desire of the self-governing colonies, as expressed at the Colonial Conferences of 1887, 1894 and 1897, to participate with the mother country in a comprehensive preferential system; (3) the actual granting of preference by the Canadian Government to the products of the United Kingdom in 1897; and (4) the receipt of definite proposals from the various dominion governments at the 1902 Conference.

The policy of free imports, however, was too deep-rooted in British state and popular tradition to be altered so readily. Furthermore, trade had been good from 1898, save for a slight reaction in 1903 and 1904. A protective tariff or any extension of customs duties for preference purposes, therefore, held little allurement for business interests and was even more distasteful to the consuming classes. The really important result of the Chamberlain campaign was that it committed the Conservative Party to the idea of a tariff for protection, although temporarily at the price of office.

From 1906 to 1914 the dominions continued to bring pressure to induce at least a change by a preference grant on existing duties. But the British Government, under Liberal leadership, adhered closely to the policy of free imports. Pressure was manifest especially in the two Imperial Conferences of 1907 and 1911. It was also brought into practical prominence by the preference grants of the various dominions in accordance with their proposals of 1902.

In a subsequent chapter, after examining the changing distribution of British trade during the period from 1900 to 1914, we noted the growing importance of the self-governing colonies and other possessions as sources of food supply, and their continued value as sources of raw materials. Moreover, as export markets they possessed considerable importance. Hence, there is reason to believe that this colonial pressure eventually might have forced the preferential principle into the British tariff, without the stimulation given to the movement by the War.

That the foregoing belief would have materialized, of course, cannot be more than asserted. The declaration of war certainly brought in its train a succession of extraordinary conditions. For example, the fact that British industry found itself without certain vital and essential commodities, whose production had been controlled by enemy interests, exerted a profound influence. It was, in fact, fundamental in causing the enactment of legislation safeguarding "key" industries soon after the close of the war, and its permanent continuance, at least as far as one can reasonably foresee, in the British tariff. With the growing intensity of popular war feeling, there came to prevail a general fear of the economic designs of the enemy countries, and a widespread delusion concerning their preparations for post-war economic conflict. The Paris Resolutions and their acceptance by a Coalition Government, in which the Liberal (free trade)

Party predominated, illustrates the importance of this force and the foregoing one.

Among other important factors, there was the opinion generally held that Great Britain would have to meet unusual competition in regaining old world markets and in securing new ones in the post-war period. The various reports of the Lord Balfour of Burleigh Committee suggest the extent to which this force was effective in influencing public opinion. The response of the dominions in supporting Great Britain in her war program is also important for us to recall at this time, because it made such an undeniably deep impression upon the British mind. The unanimous approval given the preference principle by the 1917 Imperial War Conference, and the subsequent expression in the British preference grant of the 1919 Budget, unquestionably were made possible by the war stimulus to Imperial sentiment.

The enactment of the McKenna duties was the first step taken in utilizing the British tariff for protection during the War. The continuation of these duties in the period following the War was made possible by the momentum initiated by the abovenamed forces. In other words, British statesmen and business men had come to look upon the idea of tariff protection first with tolerance and then with sympathy, themselves scarcely recognizing the many subtle forces that were at work changing their attitude.

In the post-war period, the paramount influence at work in promoting the spirit of protectionism has been the unprecedented depression in British trade and industry described in the preceding chapter. The necessity of keeping the machine going at any cost, as we emphasized earlier, has led to a grasping at every possible expedient. Mr. Baldwin's justification of his general protective proposals, when he appealed to the country in 1923, is illustrative of this. The same sort of pressure has been evident in the more recent application of the new safeguarding policy; namely, that of maintaining those industries suffering from extraordinary competition at the expense of industry as a whole. The tremendous problems which have faced the United Kingdom as a dependent manufacturing nation with a highly localized industrial population, have effected a willingness to accept a reconsideration of the tariff issue.

The post-war problems, of course, have arisen from a number of sources. Among the most important are the decline of purchasing power in overseas markets; the growth of local manufactures; and the growth of foreign commodity protection. These are complicated by the obligation to America which Great Britain has agreed to pay, and by the payment of German reparations to the Allied Powers. Certainly, a combination of such elements would seem to place the United Kingdom in a defensive position commercially, and would tend to establish a state of mind conducive to the application of all manner of protective measures.

The British preference advances of the 1923 Imperial Economic Conference and their subsequent adoption in 1925, are of considerable significance. British trade with the colonies and dominions increased from 1913 to 1926, it was pointed out, far more than it increased with other countries (although this was an increased percentage of a greatly diminished total volume). Europe, however, Britain's other large customer, was suffering from an extended depression, complicated by high tariff barriers. In addition, trade with the United States had experienced little increase over

1913. In the same period, on the other hand, there was a general increase in the average rate of preference granted by the self-governing dominions. With rising tariff barriers abroad, the experience of a war shortly past in which the colonies rendered invaluable assistance, and growing trade with the colonies, it would seem that additional developments along the line of preference would be likely. The 1926 Finance Bill, guaranteeing as it does all existing preferences for a period of ten years and the further extensions of the 1927 Budget are in confirmation of this.

The broad fact remains that Great Britain has become a protectionist nation with regard to her tariff.[3] Of course, a retreat to a complete free import policy is not outside the realm of possibilities. Yet, when we consider the extent to which tariff protectionism has been carried, and thoughtfully weigh the conditions of British and world trade, it does not seem likely that such will occur, at least in the immediate future. On the contrary, we may expect, excepting an unlooked-for trade revival, that further use of the tariff for protection will take place. Probably, it will be along lines already established; namely, safeguarding and preference. The longer the process is continued, and the deeper rooted and institutionalized the system becomes, the more concerned the vested interests will be in its maintenance, and the greater its chance of extension and permanence.

That Great Britain will become protectionist in the manipulation of her tariff to the extreme extent that some other nations, as the United States, have become protectionist, it would be beyond all reason to assert. What is evidenced by our survey of the facts is that the United Kingdom has become involved with regard to her tariff in a type of protectionism which has supplanted, to all intents and purposes, her traditional policy of customs duties for revenue only.

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[3] Despite the fact that a recent British official statement asserts that the whole of the goods liable to the "new" duties only amount to 2% or 3% of imports. See the League of Nations (International Economic Conference), *Principal Features and Problems of the World Economic Position from the Point of View of the Different Countries*, *op. cit.*, p. 25.

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HISTORIC EVIDENCE ON CHANGES IN THE CHANNEL OF RIO PUERCO, A TRIBUTARY OF THE RIO GRANDE IN NEW MEXICO

COMPLIMENTS OF THE AUTHOR

KIRK BRYAN

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HISTORIC EVIDENCE ON CHANGES IN THE CHANNEL OF RIO PUERCO, A TRIBUTARY OF THE RIO GRANDE IN NEW MEXICO[1]

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ABSTRACT

The Rio Puerco, a tributary of the Rio Grande in New Mexico, has deepened and widened its channel, or arroyo, since the settlement of the region. This process of accelerated erosion still continues. Historical evidence, largely the notes and maps of government land surveyors, is cited to show that the cutting began between 1885 and 1890. The deepening of the arroyos has decreased the agricultural and grazing value of the country, resulting in the abandonment of six small towns and numerous ranches. The coincidence between the introduction of large numbers of stock and the cutting of arroyos indicates that overgrazing precipitated this form of destructive erosion. The ultimate cause, not completely discussed in this paper, appears to lie in cyclic fluctuations in climate.

INTRODUCTION

The Rio Puerco of the East, so called by the early explorers to distinguish it from a tributary of Little Colorado River of the same name, is one of the longest streams in New Mexico. Its length from its source on the west flank of the Nacimiento Mountains to its junction with the Rio Grande at San Acacia is 149.5 miles (Fig. 1). In the first 10 miles the flow is perennial or intermittent, but for the rest of its course it is a strictly ephemeral stream. Rains on the watershed are followed by muddy floods, but for long periods the bed is dry or contains stagnant and alkaline pools fed by ground water. The variation in flow is well shown by the records of a gaging station maintained since 1913 by the State Engineer[2] of New Mexico at the Santa Fe Railroad crossing. In the 13 years 1913–25 the annual discharge ranged from 3,280 to 229,000 acre-feet. The greatest

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[1] Published by permission of J. L. Burkholder, chief engineer, Middle Rio Grande Conservancy District.

[2] George M. Neel, *Surface Water Supply of New Mexico, 1888–1925* (Santa Fe, 1926), pp. 287–90.

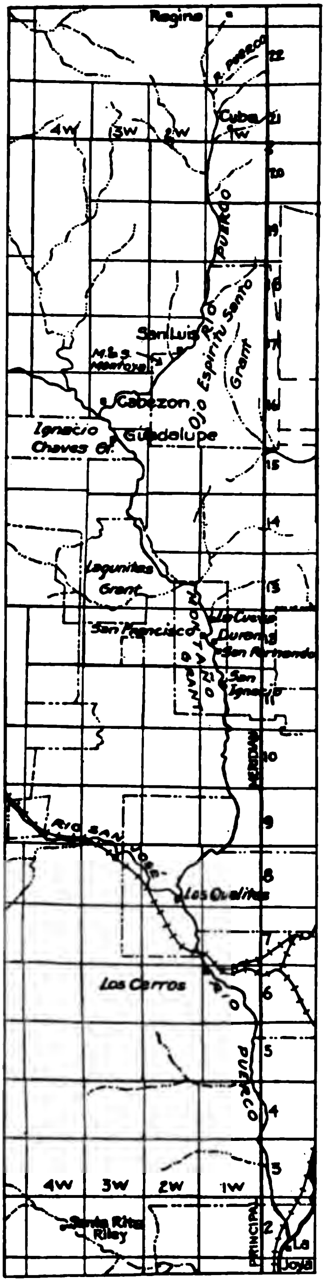

FIG. 1.—Map of the Rio Puerco, New Mexico.

flood recorded had a maximum discharge of 14,000 second-feet, but floods of twice this magnitude would doubtless be shown by a longer record.

Throughout its course the stream flows in a steep-walled gully incised in the valley floor. The valley floor varies in width from a quarter of a mile to three miles, and constitutes a terrace above the present stream grade. This terrace or abandoned flood plain is no longer overflowed, even by the largest floods. The present channel has an average depth of 28 feet and a width of 285 feet, which is more than ample, with existing grades, to accommodate floods much larger than have been observed. The channel is, therefore, a small gully and the river has, in common with other southwestern streams, begun a new cycle of erosion.

The general testimony of the older residents on the Rio Puerco is that the channel has deepened and widened within their memories. Oral tradition fixes this time of rapid deepening as the late eighties. Many testify that the river had no banks, or inconsiderable ones, and in flood spread over the whole valley floor; but the accounts of travelers indicate that at much earlier dates a considerable bank existed in certain localities. Before this study was begun, this discrepancy had been discovered and the need of additional and specific information had been recognized.[1] The opportunity for renewed historical research on the date of channel trenching of Rio Puerco came during the past summer. George M. Post, formerly an engineer in the Indian Reclamation Service, and the writer made a study of erosion and the control of silt in Rio Puerco for the Middle Rio Grande Conservatory District. The present paper is the historical section of the unpublished report resulting from this study. The writer wishes to make grateful acknowledgment of assistance to Mr. Post and other engineers of the district.

The principal new materials used in this paper are the field notes of the early public land surveys which began with the survey of the New Mexico Principal Meridian in 1855. The notes and maps of these surveys are on file in the office of the district engineer of the General Land Office in Santa Fe, New Mexico, where the search for data was facilitated and every courtesy offered. All other available information has been used in order to obtain a true picture of the Rio Puerco as it once existed and an accurate story of the changes that have taken place.

In general, the early surveyors do not comment on the height of the banks, but they usually record the distance between them, either in the line of their survey or directly across the channel. Apparently the height of the banks did not impress the early surveyors, although at the present time the difficulties of crossing the channel with a line are so great as to induce comment by the most careless note-taker. Similarly, many of the early surveyors give the width of the water that chanced to be running at the time of the survey, or the width of the bed in which they considered that water ordinarily flowed. This practice may have been due to some preconceived idea, or it may be that the banks were so low as to have been thought unworthy of comment.

Generally, the width given in the notes is the distance from bank to bank in the direction of the surveyed line, rather than at right angles to the direction of the channel or the flow of water. There are available for comparison cross-sections at right angles to flow made under the direction of George M. Post for the Middle Rio Grande Conservancy District in 1926 and 1927. These sections are not on the surveyed lines and give only an approximate comparison with the widths and depths recorded in the early surveys. A topographic map of the lower Puerco Valley, showing the position of the top of the bank, was also made by the Conservancy District in 1927. The data obtained by an intense but not exhaustive search of the records of the early government surveys have been assembled in Table I and compared with the recent surveys before noted. The material is arranged in order from the lower to the upper river, and is referred to in various parts of this discussion.

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[1] Kirk Bryan, "Date of Channel Trenching (Arroyo Cutting) in the Arid Southwest," *Science*, n.s., Vol. LXIV (1925), pp. 338–44. On the same problem, see T. T. Swift, "Date of Channel Trenching in the Southwest," *idem*, Vol. LXIII (1926), pp. 70–71; Fred Wynn, "The West Fork of Gila River," *idem*, Vol. LXIV (1926), pp. 16–17; Kirk Bryan, "Channel Erosion of Rio Salado, Socorro County, N.M.," *U.S. Geol. Survey Bull. 790* (1927), pp. 15–19.

CHANNEL NEAR CABEZON

One of the best early accounts is that of Simpson,[1] who crossed the river in 1849, about 5 miles above Cabezon. He states that the channel was 100 feet wide; it contained stagnant pools of water; the banks were 20 and 30 feet high, and had to be cut down to allow passage of the artillery. Yet in spite of these high banks, changes in the position of channels have taken place in this vicinity which would have been impossible had the river not been flowing on the grade of its flood plain. At the south end of the M. and S. Montoya Grant, about 5 miles upstream from the town of Cabezon, the west boundary of the grant enters the channel of the river without crossing it. In the survey of this grant in 1877, Watts & Pradt report that this is a new channel with "high" banks marked by recent cave-ins and falling trees. They state that it lies west of the old channel which forms the eastern boundary of the grant. In resurveying this grant in 1899, G. H. Pradt, of the same firm, comments again on this change and gives the width of this new channel, where it is crossed by the east boundary, as 132 feet. In surveying the north boundary in 1877, Watts & Pradt begin on the west bank of the river, where the banks are "high," and run west without crossing the river; but Pradt, in 1899, begins at the same point on the west bank of the "old channel" and crosses the river which

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[1] J. H. Simpson, *Journal of a Military Reconnaissance from Santa Fe, New Mexico, to the Navajo Country, etc.* (Philadelphia, 1852), p. 27.

TABLE I

MEASUREMENTS OF WIDTH AND DEPTH OF CHANNEL OF RIO PUERCO

COMPILED FROM SURVEY NOTES ON FILE IN UNITED STATES LAND OFFICE, SANTA FE, NEW MEXICO. CROSS-SECTIONS TAKEN UNDER DIRECTION OF GEORGE M. POST IN 1927 AND OTHER SURVEYS BY MIDDLE RIO GRANDE CONSERVANCY DISTRICT ARE GIVEN FOR COMPARISON

T. 3 N., R. 1 W.

LOCATION OF LINE SURVEYED	J. W. Garretson 1855		C. W. Devendorf 1920		R. A. Farmer 1922		George M. Post 1927		MIDDLE RIO GRANDE TOPOGRAPHIC SURVEY 1927	
	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Width (Feet) Normal to Channel
East boundary of Secs. 13 and 18	72.6 92.4	20	....	30 or 40	399.9	25	‡450	‡42	450* 850*	Normal to channel Immediately south, 400–450 Immediately north, 320–50‡

T. 4 N., R. 1 W.

LOCATION OF LINE SURVEYED	J. W. Garretson 1855		D. R. Cunningham 1881		W. H. Richards 1912		George M. Post 1927	
East boundary of Sec. 12	132	....	132	....	452.5	30	....	....
North boundary of Sec. 1	....	....	132	....	....	....	....	....
Line between Secs. 1 and 12	....	....	132	....	....	....	‡325	‡30
East boundary of Sec. 36	Line runs 250.8 ft. in channel without crossing		132	....	788.7	25	‡440	‡34

T. 5 N., R. 1 W.

LOCATION OF LINE SURVEYED	D. R. Cunningham 1881		William White 1897		Geo. H. Pradt 1898		J. H. Walker 1900	
North boundary, Sec. 1	99.0	....	330.7	....	....	18	531.3	....
Line between Secs. 1 and 12	165.0	....	410.5	....	960.9	16	844.8	....
Line between Secs. 12 and 13	132.0	....	....	....	....	....	....	....
Line between Secs. 13 and 24	99.0	....	....	....	....	....	....	....
Line between Secs. 24 and 25	82.5	....	....	....	....	....	....	....
Line between Secs. 25 and 36	85.8	....	....	....	....	....	....	....
So. Bdy., Sec. 36	132.0	....	....	....	....	....	....	....

TABLE I—*Continued*

T. 6 N., R. 1 W.

LOCATION OF LINE SURVEYED	D. R. Cunningham 1881		William White 1897		Geo. H. Pradt 1898		J. H. Walker 1900		Geo. M. Post 1927		Survey of Rio Puerco Reservoir 1927	
	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)
North boundary of Sec. 6	132.0	....	504.9	20	....	....	....	....	360	43	450	40
Line between Secs. 5 and 6	39.6	....	186.1	20	....	16	752.4	....	480	40	900	....
Line between Secs. 8 and 9	26.4	....	374.5	....	....	18	143.9	....	440	37	725	....
Line between Secs. 9 and 16	66.0	....	429.0	....	....	18	677.2	....	440	33	800	....
Line between Secs. 15 and 16	66.0	....	264.0	....	....	16	299.7	....	230†	46	325	....
Line between Secs. 16 and 22	66.0	....	....	....	....	15	....	....	185†	30	....	....
Line between Secs. 22 and 23	99.0	....	....	....	....	15	....	....	250†	35	....	....
Line between Secs. 23 and 26	115.5	....	493.7	....	....	15	797.94	....	160†	43	625	....
Line between Secs. 25 and 26	132.0	....	653.4	....	....	18	665.3	....	280†	42	550	....
Line between Secs. 25 and 36	99.0	....	863.3	....	....	14	559.2	....	370	27	....	....
So. Bdy., Sec. 36	132.0	....	330.7	....	....	18	531.3	....	....	....	....	....

T. 7 N., R. 2 W.

	R. G. Marmon 1875–76		Geo. M. Post 1927	
North boundary of Sec. 2	198.0	....	‡600	‡15

Bernabe M. Montaño Grant

	Sawyer and White 1877		H. T. Brown 1894		H. T. Brown 1896		Geo. M. Post 1927	
Unconfirmed south boundary near crossing on east boundary of surveys from 1894 to date	86.8 Bridge South 1,700 ft.	High	165.0	....	....	....	‡130	‡37
Unconfirmed west boundary near crossing of north boundary of surveys from 1894 to date	....	Sandy banks	....	....	290.4	....	‡210	‡15

T. 17 N., R. 2 W.

	J. H. Walker 1906		Geo. M. Post 1927	
North Bdy. of Sec. 1	207.0	15	‡110	‡8.5
Line between Secs. 1 and 12	198.0	....	‡155.0	‡5.5
Line between Secs. 11 and 12	99.0	....	‡98	‡18
[illegible]	[illegible]	....	[illegible]	[illegible]

LOCATION OF LINE SURVEYED	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)
	T. 19 N., R. 1 W.											
	H. M. Neighbor and G. P. Harrington 1923		Geo. M. Post 1927									
South boundary of Sec 31	198.0	15	‡185	‡41								
	T. 20 N., R. 1 W.											
	J. F. Thomas 1906		Geo. M. Post 1927									
South boundary of Sec. 31	183.5	10–16	‡143	‡15								
	T. 16 N., R. 3 W.											
	A. F. Compton 1910		Geo. M. Post 1927									
Line between Sections 13 and 14	391.4	30	‡210	‡34								
Line between Sections 14 and 15	184.8	30	‡177	‡35								
Line between Sections 15 and 16	214.5	25	‡340	‡35								
	M. and S. Montoya Grant											
	Pradt & Watts 1877		G. H. Pradt 1899		J. H. Walker 1906		Glenn R. Haste 1922		Geo. M. Post 1927			
North boundary	No new channel	High	New channel 198	....	New channel 224.4	20	....	....	98	22		
West boundary	New channel reported 495.0	....	495.0	....	....	....	....	....	But 1.2 miles downstream 342	35		
East boundary Near SE. corner	....	High	231 (true width is 132)	....	....	....	....	....	215	35		
Near NE. corner	....	....	99	....	....	....	....	....	....	....		
West boundary of T. 16 N., R. 2 W. at Sec. 18, about 1 mile downstream from above (calculated width of river)	....	....	....	....	....	....	1,384.5	....	207	30		

TABLE I—*Continued*

LOCATION OF LINE SURVEYED	Nuestra Señora de la Luz de las Lagunitas del Rio Puerco Grant											
	S. C. McElroy 1877		J. H. Walker 1901		Miller & Lyman 1915		Geo. M. Post 1927					
	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)	Width (Feet)	Depth (Feet)
North boundary	‖26.4	High			823.8 165.0	30 40	‡110	‡18				
Southeast corner	‖79.2	High	138.6				‡210	‡15				
	T. 15 N., R. 3 W.											
	J. W. Walker 1906		Geo. M. Post									
South boundary of Sec. 35	405.9	10–15 Records river change since earlier survey by shift to the east	‡212	‡18								
	Ignacio Chaves Grant											
	Pradt & Watts 1878–79		A. F. Easley 1879		A. F. Compton 1910		Geo. M. Post 1927					
Preliminary east boundary. This line crosses at small angle bridge 400 feet south	733.9											
North boundary			175.0	8	735.9	30	‡240	‡30				
South boundary	145	High	167.6	15			‡132	‡41				

* In line of survey.

† In narrow places; wider places are 1,000 feet or more.

‡ Nearest cross-section.

§ San Luis diversion dam, a structure of logs and brush, holds river channel to or above original depth in this area.

‖ Measurement may refer to water in the channel, and not to channel.

occupies a "new channel," 198 feet wide. J. H. Walker, in 1906, found that this "new channel" was in the same location and was 224.4 feet wide and 20 feet deep. These surveys establish considerable lateral shifts of the river channel, which took place in spite of its high banks, and were, as will be seen, in part induced by the activity of settlers.

Meliton Cordova, now a resident of Albuquerque, went to Cabezon about 1870, when he was a small boy. The flood plain of the Puerco was without a deep channel. There were large groves of cottonwood trees and high grass and weeds. It was necessary for the settlers, in order to find the cattle, to climb the hills and look down into the valley. There was a bridge over the river, but it was small, such as is used to cross an *acequia*, or irrigating ditch, in the Rio Grande Valley.

One man could build a dam for diverting the river by felling a cottonwood tree across the channel and using the branches to fill in the chinks of the dam. The dam at San Luis was built about 1875, but it was then a very small affair of brush and poles. The river washed around it during a flood and this caused the channel change, recorded in the surveys of the north boundary of the Montoya Grant by Watts & Pradt (1877) and Pradt (1899). Similarly, the channel change at the lower end of the Montoya Grant, recorded in the survey of Watts & Pradt of 1877, was caused by the activity of William Kensenbach, a settler, who in that year diverted flood waters from the hills into a line of little ponds and depressions on the west side of the valley. Thus a channel was begun, and when a flood on the Rio Puerco washed around the Cabezon dam, which lay upstream, the waters enlarged this channel and made it permanently the channel of the river.

Don Amado Chaves, now a resident of Santa Fe, crossed the Rio Puerco frequently during several years after 1876 on the road from Santa Fe to San Mateo by way of Cabezon. During this period the river channel was shallow and the bottom was corduroyed with large logs so as to make the muddy bottom passable for carriages. These logs were occasionally washed away.

Restituto Sandoval, a resident of Cabezon, visited the place first as a boy of thirteen, in 1882. There was then a small bridge over the river, not over 5 feet high. When he returned the next year to take up permanent residence this bridge was useless, for in the meantime the channel had changed position. It seems likely that it was such a bridge as this which Jackson[1] crossed in 1877. According to Don Amado Chaves, a corduroy was also used at this time. These small structures were not intended to make the valley passable during great floods, which, according to Restituto Sandoval, spread over the banks of the channel and covered the whole valley. Overtopping of the banks at Cabezon is now impossible and has been since before 1910, for the channel was then about 35 feet deep and a veritable canyon, as shown by the subdivision survey and plot of T. 16 N., R. 3 W., made by A. F. Compton in that year. After the deep channel was cut, a well at Sandoval's house went dry and was abandoned. At the present time he and the other inhabitants of Cabezon must haul water from a small reservoir 3 miles west. He believes that the river cut down and the well went dry between 1885 and 1890.

Meliton Cordova moved away from Cabezon in 1900, because he could no longer cultivate successfully and the town was not prosperous. He believes that the channel began to get deep about 1890 to 1892.

About 10 miles below Cabezon, J. W. Walker, in surveying the south boundary of T. 15 N., R. 3 W., in 1906, found a channel 405.9 feet wide on the line of his survey, and with banks 15 feet high. It was not in the position of the river bed given by earlier surveys, where, however, he found a depression trending NE. and SW. His notes state that this is the former position of the river, as old settlers tell him that the river once spread over the entire valley and that the present bed has been formed since the earlier surveys.

Meliton Cordova, previously mentioned, says that there was always a well-defined channel below the "Salta" or rock falls at Guadalupe, that is, in the area surveyed by Walker. However, above Guadalupe the channel was insignificant. This is confirmed by the statement of Alcario Montoya, who crossed the Puerco at Guadalupe in 1887, and remembers that the channel was about 3 feet deep and 30 feet wide. These statements may be compared with data given by early surveys of the Lagunitas Grant, on which Guadalupe is located. McElroy, in 1877, gives the width of the river as 26.4 and 29.2 feet at the north and south boundaries of the grant, but his notes are not clear as to whether this distance is from bank to bank or merely the width of the water flowing at that time.

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[1] W. H. Jackson, "Report on the Ancient Ruins Examined in 1875 and 1877. Chapter II, Ruins of the Chaco Canyon Examined in 1877," *U.S. Geol. and Geogr. Surveys. Terr.* (Hayden Survey), 10th Annual Report (1878), p. 432.

Above Cabezon, early surveys that give the width and depth of channel have not been found, but in T. 17 N., R. 2 W., deepening and widening of the channel since 1906 is shown, except where the San Luis Dam has raised the stream grade. According to Epitacio Salas, who was born in La Ventana in 1874, the channel there, when he was a boy, was about 8 feet deep, whereas now it is 40 feet deep. There was a small channel at Cuba; but midway to La Ventana and opposite La Vega de China, where the Señorito and San Pablo creeks enter the river, the valley floor of the Puerco was a smooth plain. He remembers this fact because as a boy he crossed the river with a band of ewes.

CHANNEL IN THE MONTAÑO GRANT

Further south, on the Montaño Grant, Abert[1] reached the Rio Puerco in 1847 at a point west of Albuquerque, where the banks were "10 or 12 feet high" and vertical. He must have arrived at the Puerco near the site of San Ignacio, which did not exist at that time, and he camped farther upstream near a ruined town which he heard afterward was called "Poblazon," and here the banks of the river were 30 feet high.

On the map resulting from their survey of 1877, Sawyer and White show four towns on this grant: La Cueva, on the east bank, with three houses (in Sec. 7, T. 12 N., R. 1 W., projected); San Francisco, on the west side of river, with four houses (in Sec. 18, projected. This is in error, for in 1909 there were ruins of ten or fifteen houses); Duran, with three houses (at corner of Secs. 19 and 20, projected); San Ignacio, on east bank, with eight houses (in Sec. 9,

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[1] Lieutenant J. W. Abert, "Report of His Examination of New Mexico in the Years 1846–47," *Ex. Doc. 41*, 30th Congress, 1st Sess. (1848), pp. 466–67; also printed as *Sen. Ex. Doc. 23* (1848), pp. 50–51.

T. 11 N., R. 1 W., projected; more houses in 1909). They credit San Francisco, also called Ojito, with more than 100 inhabitants, and San Ignacio, also called Atarque, with 150 inhabitants.

H. T. Brown surveyed the grant in 1894 and in 1896. In his notes he describes the ruined town of Nuestra Señora de la Luz San Fernando y San Blas del Rio Puerco as situated on the east side of the river, midway between San Francisco and San Ignacio, near the point of the Mesa Baptiste (Bautista). The ruins covered an area of 330 by 400 feet, and were seen by me in 1909. According to contemporary legal documents, this town[1] was settled by twelve families in 1753, occupied for 20 years, and abandoned because of hostility of the Indians. Brown notes that San Francisco and San Ignacio were nearly deserted in 1894. In 1896 work was being carried on in the building of dams and other works of the English company which attempted to irrigate the grant at this time. After the failure of this project San Francisco was deserted, and even the memory of La Cueva and Duran was lost. San Ignacio, reduced to about fifty people, persisted until 1911, but practically no farming was carried on, the inhabitants living by stock-raising and freighting. At that time the owners of the grant bought the improvements and some of the people settled west of the grant at Ojo Hediondo, where the post-office of San Ignacio is now located.

CHANNEL SOUTH OF SANTA FE RAILROAD

South of the Santa Fe Railroad the banks were, according to statements of early residents, generally low. However, J. W. Garretson, in running the Principal Meridian, gives the height of the banks as 20 feet and the width 132 feet where he crossed the river in Sec. 13, T. 3 N., R. 1 W. In Figure 2 the channel recorded by Garretson is compared with the topographic map of the Middle Rio Grande Conservancy District. At his crossings in the next township north he does not mention the height of the banks. D. R. Cunningham, who subdivided Townships 3, 4, 5, and 6 N., R. 1 W., in 1881, does not give the height of the bank, but records a channel from 1 to 2 chains (66 to 132 feet) wide. These are, undoubtedly, merely estimated widths, but the most careless surveyor could not estimate the present channel as so narrow. The later surveys in this vicinity also show a progressive widening and deepening which began after 1881. That the river in places had a shallow channel in 1881 is also indicated by a lateral shift, or new channel, recorded in the survey of T. 6 N., R 1 W., and by Cunningham's note: "Water taken from the river for irrigation near village of Los Cerros in Section 6. Village has 50–60 inhabitants who cultivate land in Sections 5, 6 and 8." Remnants of a brush and rock dam used for diversion were found in 1927 by Mr. George M. Post, about 2 miles south of the A. T. & S. F. Railway, and therefore in a suitable place to divert water for the lands at Los Cerros. The base of the remnant of this dam is, according to a measurement by Mr. Post, 22 feet above the bottom of the 1927 channel of the Rio Puerco. This dam, according to local people,

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[1] R. E. Twitchell, *The Spanish Archives of New Mexico*, Vol. I (1914), pp. 90–92 *et al.*

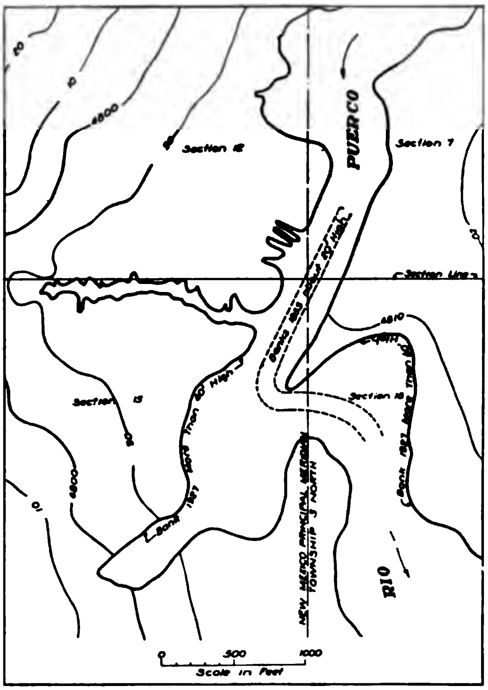

FIG. 2.—Map of the channel of Rio Puerco in T. 3 N., R. 1 W., as surveyed in 1927, and channel recorded by Garretson in 1855.

was in use as late as 1887. For instance, Fred F. Chavez, of Albuquerque, remembers going to Los Cerros to hoe corn when he was a boy of eleven, or in 1886. As late as 1895 or 1896 he remembers, on a trip to the west from Belen, that he saw corn growing at Los Cerros; but he believes that it was irrigated by flood water from the hills, as he remembers that the dam washed out when he was still a boy. Evidently the deep channel of the Rio Puerco worked headward into this area, requiring a substantial diversion dam in the later years of occupation, but when this structure washed out, the people became discouraged and abandoned the town of Los Cerros. Thus the river had a shallow, narrow, and shifting channel as late as 1881, and diversion was possible as late as 1887; but 20 miles to the south, 20 foot banks, as recorded by Garretson, characterized the channel as early as 1855.

REVIEW OF EVIDENCE

A review of the evidence presented in the foregoing and in Table I indicates that the earliest records prove definitely that at places the Rio Puerco had banks as high as 20, and even 30, feet. At other places the banks were so low and inconspicuous as not to be recorded. In floods, most of the valley floor was inundated, and in those years good crops of wheat, corn, and beans were raised. Natural hay fields in the valley floor or in the tributary valleys were irrigated by these overflows, and the hay cut was hauled to Albuquerque as late as 1895. One large livery stable used regularly about 10 tons a month. These hayfields are recorded in place names such as Vega Quelites, at the mouth of San José River, Vega Verde, just south of Ojito, on the Montaño Grant, and La Vega de la China, between Cuba and La Ventana.

During the inundations of the valley floor the river channel might shift materially. Some of these shifts north of Cabezon, as recorded by the successive surveys, are of artificial origin. Others, of doubtless more ancient date, are recorded in this area by numerous corrugations of the valley floor. These abandoned channels are 2–10 feet deep and 25–150 feet wide. In them once lay the pools of water which old settlers call *lagunitas*, a name perpetuated in the Lagunitas grant.

Deep and fairly stable channels were doubtless formed at certain localities. The entrance of large tributaries, narrowness of valley floor, and other factors determined the location, size, and the period of duration of these channels. The Rio Puerco was, previous to the late eighties, an ephemeral stream of great length, subject to numerous floods of short duration, but occasionally of great magnitude. It flowed in a flood plain subject to overflow and had a discontinuous channel. The discontinuity of the channel affords a rational explanation of the otherwise conflicting historical evidence on the character of the valley and its watercourse.

The new deep channel was formed from the mouth headward. Thirty-four miles above the mouth, Los Cerros was abandoned about 1887. San Ignacio, 62 miles, and San Francisco, 73 miles, were nearly abandoned in 1894, and the channel doubtless deepened some years before, as the nearby La Cueva and Duran were already abandoned. The deep channel reached Cabezon, 110 miles from the mouth, between 1885 and 1892. It is, therefore, fair to say that the cutting of the existing deep arroyo on the Rio Puerco took place in the late eighties, although the completion of the work and the extension of the arroyo headward into the tributaries is still in progress.

QUANTITY OF MATERIAL ERODED'

As a result of surveys made by George M. Post for the Middle Rio Grande Conservancy District, the cubic volume of the present channel of the Rio Puerco and the channels of its tributaries can be estimated. The volume of the original channels can be estimated from the historical data hereinbefore presented. The original channels were less than 5 per cent of the existing channels. Mud and silt have been swept out of the Rio Puerco into the Rio Grande in the past 42 years to the amount of 394,882 acre-feet, or at an average rate of 9,400 acre-feet a year.

OVERGRAZING IN RELATION TO THE DEEPENING AND WIDENING OF ARROYOS

It has long been contended that the decrease in vegetative cover brought about by the introduction of live stock promotes run-off.

The more rapid run-off increases the magnitude of floods and the erosive and transporting power of streams. The Indians of pre-Spanish days lacked domestic animals, except the dog, although they kept and herded in the fields large numbers of turkeys. Herbivorous live stock were introduced by the Spanish, who first entered the region in 1540,[1] but did not found settlements until Oñate's Conquest, in 1592. For some time later the Puerco watershed was largely Indian country. It appears that settlement did not take place until the latter part of the eighteenth century.[2] These settlers were continuously harassed by Navajo raiders and were ordered to retire to the Rio Grande Valley in 1823 for lack of military protection. The number of live stock grazed in the area by these people was doubtless small, although the inhabitants of the Rio Puerco north of Cabezon claimed to have 10,000 head of cattle at this time.[3] Even after they left, some live stock were kept in the area, for we know from Pattie's narrative and other contemporary sources that the Navajos maintained both horses and sheep before 1825. After several ineffective campaigns the Navajos were finally conquered in 1865. Settlement was begun in the seventies, and efforts were made to have the Spanish grants confirmed as evidenced by the surveys of 1877–79, already mentioned. The country was not fully stocked with cattle until after 1880. As brought out on p. 274, destructive erosion followed promptly in the period 1885–90.

The time relations are thus favorable to the claim that overgrazing is the cause of arroyo-cutting. There must have been, however, a very nice adjustment of climate so that sufficient vegetation would grow to prevent erosion, but not so much but that the reduction of that vegetation by grazing would precipitate destructive erosion.

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[1] R. E. Twitchell, *Leading Facts of New Mexico History*, 5 vols. (1911 and later).

[2] In R. E. Twitchell, *Spanish Archives of New Mexico*, Vol. I (1914), note claims of Joaquin Mestas, 1762–68, on pp. 159–60; M. and S. Montoya grant, possession given 1766, on pp. 161–62; Lagunitas grant, first given to Antonio Baca in 1761, on p. 41; Montaño grant, given in 1753, inhabited 20 years, pp. 90–92; litigation, 1753–59 and 1767, on p. 189; 1767, on p. 162; 1770, on p. 83; Agua Salada grant, given to Luis Jaramillo, 1769, on p. 128; Los Quelites occupied by Antonio Sedillo, *cerca* 1762–66, on p. 70.

[3] R. E. Twitchell, *ibid.*, p. 41.

On Chaco River,[1] a similar stream some 70 miles northwest, an arroyo has been cut since 1860. Previously, however, an arroyo similar to the modern arroyo was formed in late prehistoric time. This channel was filled with alluvium and the floor of the valley once more became a true flood plain. Obviously the erosion of this prehistoric arroyo could not have been brought about by overgrazing. On Rio Puerco a similar ancient arroyo, completely filled by renewed sedimentation, has been discovered. No human relics by which its age might be determined have been found, but it is similar in appearance to the buried arroyo of late prehistoric date in Chaco Canyon. Thus on both of these streams cyclic changes from sedimentation to erosion and back to sedimentation took place before the introduction of live stock and the formation of the existing arroyos. It appears inherently most probable that these cyclic changes have a common, and doubtless a climatic, cause. The introduction of livestock and the ensuing overgrazing should be regarded as a mere trigger pull which timed a change about to take place.

CONCLUSION

Historical evidence is presented which shows that on the Rio Puerco there existed before 1885 a small channel that in places had banks 10–20 feet in height and in other places was insignificant. Floods spread over the valley floor, which was a true flood plain. From 1885 to 1890 the channel was deepened and widened, a process still continuing on both the river and its tributaries. The valley floor has been abandoned as a flood plain.

The effect of this destructive erosion on agriculture and grazing has been disastrous. Six towns have been abandoned, and some of the remaining settlements have been impoverished. Silt to the amount of 9,400 acre-feet a year has been poured into Rio Grande Valley. It has choked the channel of that river and increased the damage from flood. A large proportion of this silt has been carried into Elephant Butte Reservoir, and reduces the storage space for water. As arroyo-cutting progresses, flood damage and loss of storage will continue. The prevention of further cutting by the arroyos and the restoration of the stream channels to something like their pristine condition is a practical problem of large importance. Rehabilitation of the Puerco watershed seems feasible from both the physical and economic aspects, but discussion of these matters lies outside the scope of this paper.

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[1] Kirk Bryan, "Recent Deposits of Chaco Canyon in Relation to the Life of the Prehistoric Peoples of Pueblo Bonito" (abstract), *Wash. Acad. Sci. Jour.*, Vol. XVI (1926), pp. 75–76.

The deepening and widening of the channel of Rio Puerco is an example of changes in the channels of ephemeral and intermittent streams which have been coincident with settlement and the introduction of live stock throughout the Southwest. The ultimate cause of these changes can only be completely evaluated by means of careful historical study.

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UNITED STATES
DEPARTMENT OF AGRICULTURE
CIRCULAR No. 37

Washington, D. C. **August, 1928**

The Protection Forests of the Mississippi River Watershed and Their Part in Flood Prevention

By

E. A. SHERMAN
Associate Forester, Forest Service

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON
1928

THE WHITE HOUSE,
Washington, June 1, 1928.

MY DEAR MR. SECRETARY: The President directs me to call your attention to the last provision of section 10 of the act "For the control of floods on the Mississippi River and its tributaries, and for other purposes," approved May 15, 1928, and to request that you ascertain and report to him the extent to and the manner in which the floods in the Mississippi Valley may be controlled by proper forestry practice.

The provision referred to is as follows:

"That the President shall proceed to ascertain through the Secretary of Agriculture and such other agencies as he may deem proper, the extent to and the manner in which the floods in the Mississippi Valley may be controlled by proper forestry practice."

Sincerely yours,

EVERETT SANDERS,
Secretary to the President.

Hon. WILLIAM M. JARDINE,
Secretary of Agriculture.

JUNE 4, 1928.

DEAR MR. PRESIDENT: In compliance with the terms of your letter of June 1, I have the honor to submit herewith an initial report by Associate Forester E. A. Sherman with reference to the relation of forestry to the control of floods in the Mississippi Valley. Some mimeographed copies of this report have been distributed, but, in view of the importance of the subject matter in relation to the general problem of flood control on the Mississippi River, it is believed that the publication and more general distribution of the report would be in conformity with the provision of the act of May 15, 1928.

In compliance with your letter, this department will at once proceed to make such additional studies and to collect such additional data with reference to the relation of proper forestry practice to flood control as prove to be practicable with the present appropriations and personnel of the department and will submit the results of such studies as soon as they take definite form.

Sincerely yours,

W. M. JARDINE, *Secretary.*

The PRESIDENT, *The White House.*

CIRCULAR No. 37 AUGUST, 1928
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

THE PROTECTION FORESTS OF THE MISSISSIPPI RIVER WATERSHED AND THEIR PART IN FLOOD PREVENTION

By E. A. SHERMAN, *Associate Forester, Forest Service*

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FOREWORD

In times past, even before the white man had disturbed the heavy forests of the Mississippi River Basin, floods were known there. With the settlement of the country, forest fires, overcutting, and the abuse of forest and other lands have served to increase the possibility of floods and their severity and the amount and extent of erosion. Forests have a part in the general flood and erosion problem, and it is well that this part should be recognized. It should be emphasized, however, that it is not proposed that forestry should supplant engineering works in flood control but that forestry should supplement whatever means of artificial control may be adopted by engineers.

A program of sound forestry development that will permit the forests of the Mississippi River Basin to exert their greatest influence on the regulation of water flow should include protection of all forest lands against fire, the reforestation of all denuded lands unsuited for agriculture, the extension of proper forest practices to all forest lands, the public ownership of particularly critical areas, the continuance of existing public forests, and placing the public grazing

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lands under management. This program should be supplemented by additional research and investigation of ways and means for the better handling of forest lands as a means of controlling erosion and minimizing floods.

INTRODUCTION

The Mississippi River, from time immemorial and until prevented by artificial barriers, was accustomed every few years to inundate about 30,000 square miles of land. This ancient flood plain, which under levee protection had been developed into a very rich territory, was the scene of the flood of 1927 (fig. 1), the greatest physical disaster in American history. Uncontrollable waters inundated about 18,000 square miles of country and dispossessed about 750,000 people of their homes, some temporarily and some permanently. The property loss was appalling. Fortunately, about 12,000 square miles of the richest portions of the ancient flood plain, as well as the city of New Orleans, were saved by protecting levees.

This disaster removed every doubt that the problem of controlling floods on the Mississippi River is a national responsibility, challenging the best efforts of every public agency. The Forest Service responded by promptly undertaking an investigation of the forests and forest lands of the Mississippi watershed to determine their relation to the great flood problem and the measure in which they might be made to contribute to its solution. The purpose of this publication is to present in broad outline the fruits of that study.

The study did not include the special field of the engineer who seeks to control floods by such structures as levees, spillways, and reservoirs, a field already filled by the Mississippi River Commission and the engineers of the War Department. It did include an investigation of land-surface conditions, particularly in forest regions, with a view to determining if better land use might lower flood crests and reduce flood hazards. The activities recommended as a result of this study are proposed as supplementary to engineering works and in no sense as an alternative.

SCOPE OF STUDY

While this is primarily a report on the protective influence of Mississippi Valley forests, the study upon which it is based necessarily covered surface conditions and land use generally. The starting point was the self-evident fact that the condition of the land surface has a direct influence on the amount of water held and retained by the soil, on the time and rapidity of run-off, and on the silt content of streams contributing to floods, as well as on the volume, velocity, and turbidity of the water itself. It follows that any form of land use which affects the condition of the surface has a direct bearing on the run-off from that land.

One of the important uses of land surface is for the production of forest crops. Land so used constitutes about one-fifth of the total land surface of the basin. The forests usually occupy regions of relatively heavy rainfall, and embrace a large percentage of the areas of roughest topography and greatest elevation. These are, generally speaking, the regions from which run-off is most rapid. Such forest lands doubtless play a relatively larger part in the flood problem than mere area would indicate. Determining what areas

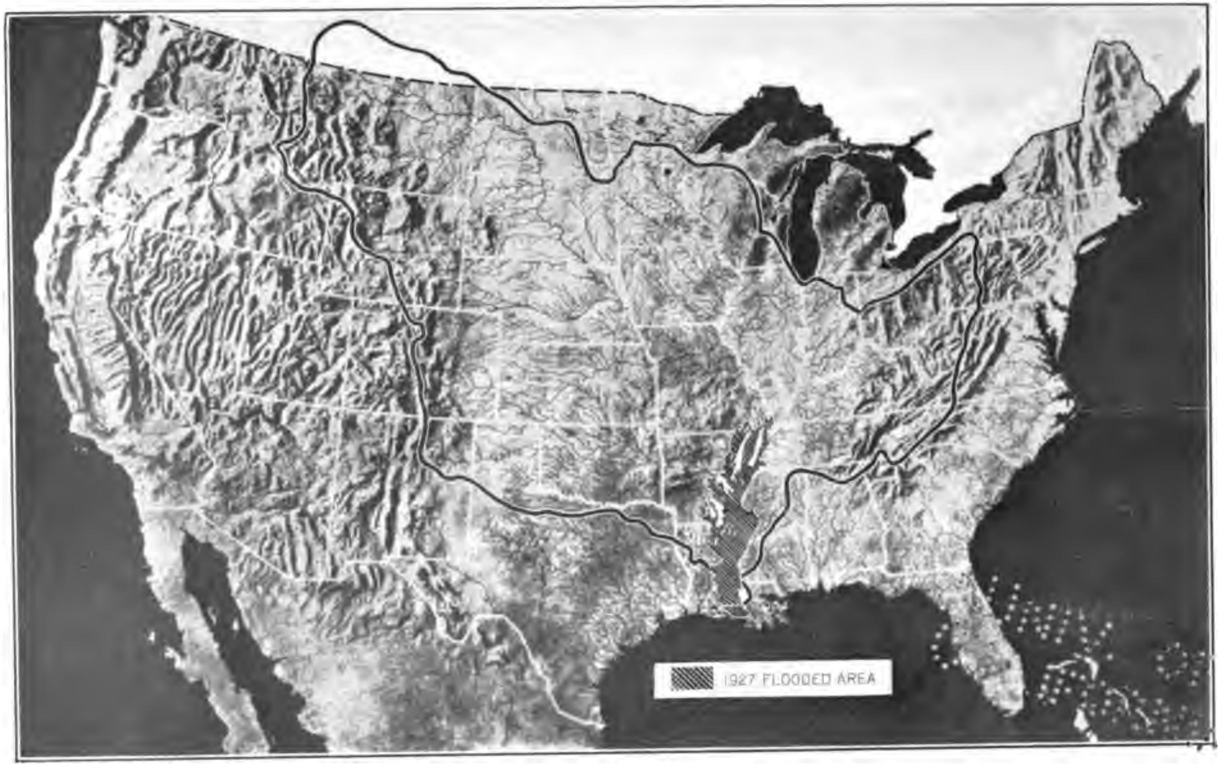

FIG. 1.—TOPOGRAPHY AND FLOOD PLAIN

are now in forests or could advantageously be reforested and estimating their influence on run-off and stream-flow condition come within the field of Forest Service responsibility. This study was limited to that field, excepting as studies of range, pasture, agricultural, and even barren lands were necessary to determine whether or not the extension of forests to lands of some other class was practicable or desirable. The field of this study obviously covered activities and conditions which are factors entering into the flood problem but which do not usually come within the field of the construction engineer's observations and operations.

MISSISSIPPI WATERSHED ALWAYS LARGELY NONFOREST LAND

The Mississippi Basin has always been conspicuous among the great river basins of the world for its large percentage of nonforest land. (See fig. 4, p. 16.) Comparatively speaking, it has always been a lightly forested country. Originally 60 per cent, it is now 80 per cent, nonforest land.

Also floods in the Mississippi have been recorded as far back as history reaches. De la Vega, in describing the difficulties encountered by De Soto's men when, following their leader's death, they determined to build boats and descend the Mississippi, says:

> Then God, our Lord, hindered the work with a mighty flood of the great river, which, at this time, began to come down with an enormous increase of water, which in the beginning overflowed the wide level ground between the river and the cliffs; then little by little it rose to the top of the cliffs. Soon it began to flow over the fields in an immense flood, and as the land was level, without any hills, there was nothing to stop the inundation. The flood was forty days in reaching its greatest height, which was the twentieth of April, and it was a beautiful thing to look upon the sea where there had been fields, for on each side of the river the water extended over twenty leagues of land, and all of this area was navigated by canoes, and nothing was seen but the tops of the tallest trees.

The report on this river submitted in 1861 to the Bureau of Topographic Engineers, War Department, by A. A. Humphreys and H. L. Abbot lists floods as having occurred in 1718, 1735, 1770, 1782, 1785, 1791, 1796, 1799, 1809, 1811, 1813, 1815, 1816, 1823, 1824, 1828, 1838, 1844, 1847, 1849, 1850, 1851, 1858, and 1859. The serious floods of more recent times have been in 1882, 1892, 1897, 1898, 1903, 1907, 1912, 1913, 1916, 1920, 1922, and 1927. The highest recorded stage of water previous to 1927 on the lower portions of the river, was reached by the flood of 1922.

It is difficult to make a fair comparison as to severity, between the later floods and those of earlier times. Before the construction of levees high water every year inundated a considerable area of low country. Naturally, as the levee system has been constructed and the stream confined, the tendency has been for the waters to reach higher and higher levels. Even without any increase in precipitation or run-off, this would be the natural result of excluding the flood waters from lands formerly subject to overflow.

It was early evident that for reliable information on how run-off was being influenced by the presence or absence of forests, a study must be made in detail of the actual source of run-off. The regimen of a stream at any given point is a composite of all factors influencing run-off from the entire area above. Influences constructively beneficial on one drainage unit may be neutralized by destructive factors on some other contributing stream. Obviously the flood waters as they reach the leveed region are a mixture coming from all kinds of watersheds, some well protected, some poorly, some not at all.

The total area of the Mississippi River Basin, within the United States, including the lands subject to inundation, is 1,231,492 square miles. So vast an area is hard to treat as a unit. Diversity of climate, cover, and human use adds complexity to immensity. Although only about 244,000 square miles of forest lands, or about 20 per cent of the total area, are involved in the problem, these forest lands are distributed throughout the humid portions of the entire basin. Furthermore, the use of forest lands must be coordinated on a practical basis with the use of other kinds of lands adjoining.

Though the source of the great volume of water in the 1927 flood was largely the run-off from heavy and prolonged rainfall in the lower central valley, at the same time a factor to be reckoned with at all times is the contribution which each individual drainage unit may reasonably be expected to make to the main flow at any given time. For a thorough understanding of the problem it was therefore necessary to consider the watershed both in detail and as a unit.

IMPORTANT DATA LACKING

In the course of this study it was found that reliable data essential to accurate determination were in many instances nonexistent. Topographic maps, soil maps, forest maps were too often lacking for important regions.

It seems fundamental to a carefully planned study of land use, covering long-time periods, that there be available accurate data for each of the major tributaries of the river showing annual and periodic run-off and total and periodic volumes of silt content. Dependable data on silt content were woefully lacking. Determinations made many years ago could not be checked against similar data of more recent date because recent measurements had not been made. A complete record of stream-flow measurements and silt determinations at some point below Cairo and on each of the principal tributaries entering the Mississippi River below that point and covering the past four decades would have been of inestimable value in this study. Such records beginning in 1928 would become increasingly valuable from year to year. Regardless of any light the data might throw on the flood problem, it would give a splendid check on the problem of land use and the trend of soil erosion. By means of such records it would be possible at any time to determine whether or not efforts in reforestation, forest protection, contour plowing, and farm terracing were reducing the burden of silt in the river at Cairo or in any of the tributaries under observation. For that reason the absence of such data is noted in this report, and the desirability of securing accurate information of this kind is given a place in the conclusions and recommendations.

MAJOR BASINS OF THE MISSISSIPPI

A systematic investigation of the forested watersheds of the Mississippi Valley and their relation to the floods of that river required a somewhat arbitrary subdivision of the entire region, first into major basins and then into individual drainage units.

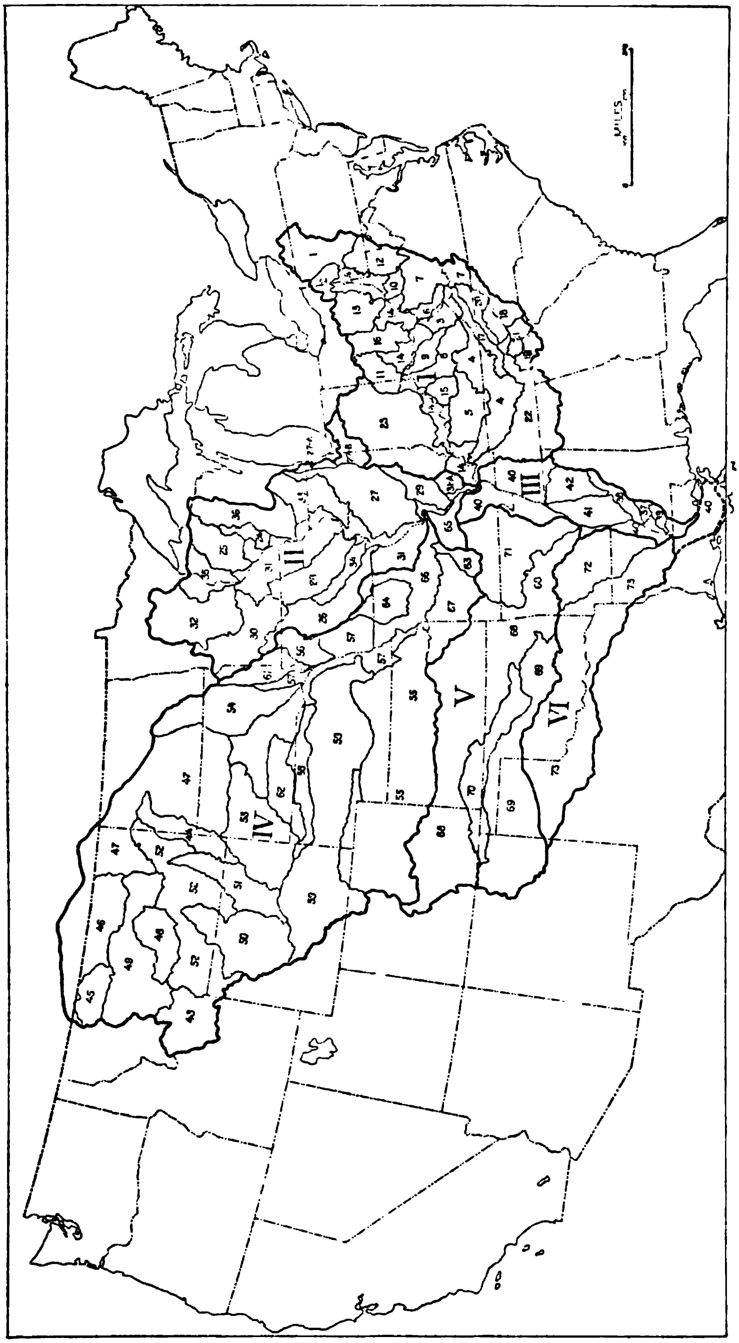

FIG. 2.—Index of major and minor basins

The subdivision into six major basins which was finally adopted for this study is shown in Figure 2. This subdivision appears to be generally followed, with perhaps some minor modifications, by all agencies in studying the Mississippi flood problem. It follows largely the classification used in the report of 1861 by Humphreys and Abbot. These authors, however, treated the St. Francis River and the Yazoo Basin each as distinct major basins. The subdivision of the major basins into principal drainage units used by the Forest Service in making the study, with the areas of each major basin and each drainage unit thereunder, is shown in Table 1.

TABLE 1.—*Mississippi River drainage—Areas of major and minor basins within the United States*[1]

Basin and river number	Area
	Square miles
Ohio River:	
1. Allegheny	11, 683
2. Beaver	3, 182
3. Big Sandy	4, 259
4. Cumberland	17, 939
5. Green	9, 329
6. Guyandot	2, 354
7. Kanawha	12, 303
8. Kentucky	6, 945
9. Licking	3, 742
10. Little Kanawha	2, 382
11. Miami	5, 352
12. Monongahela	7, 339
13. Muskingum	8, 052
14. Ohio (direct)	26, 239
15. Salt	2, 986
16. Scioto	6, 361
Tennessee	40, 423
17. Clinch	4, 278
18. French Broad	5, 052
19. Hiwassee	2, 702
20. Holston	3, 826
21. Little Tennessee	2, 549
22. Tennessee (direct)	22, 016
23. Wabash	32, 912
Upper Mississippi River[2]	
24. Black	2, 920
25. Chippewa	9, 379
26. Des Moines	14, 184
27. Illinois	21, 631
27a. DesPlaines	1, 425
27b. Kankakee	5, 188
28. Iowa-Cedar	12, 496
29. Kaskaskia	5, 812
30. Minnesota	16, 264
31. Mississippi (direct—below St. Paul and above junction with Missouri on west side and above junction with Ohio on east side)	34, 300
31a. Big Muddy	2, 402
65. Mississippi (direct—on west side between Missouri and Ohio River junctions)	5, 748
32. Mississippi (above St. Paul)	20, 449
33. Rock	10, 765
34. Skunk	4, 323
35. St. Croix	7, 664
36. Wisconsin	11, 903
Lower Mississippi River:[2]	
37. Bayou Tallahala	1, 046
38. Big Black	3, 559
39. Homochitto	1, 261
40. Lower Mississippi (direct)[3]	33, 002
Lower Mississippi River—Continued.	
41. Yazoo (bottomlands)	7, 324
42. Yazoo (highlands)	6, 496
Missouri River:	
43. Jefferson-Madison-Gallatin Forks	13, 949
44. Little Missouri	9, 351
45. Marias	7, 079
46. Milk	15, 042
47. Missouri (direct—Cheyenne River to mouth of Milk River)	52, 708
48. Musselshell	9, 606
49. Upper Missouri (above Milk River)	26, 827
Yellowstone	70, 172
50. Big Horn	23, 057
51. Powder	13, 480
52. Yellowstone (direct)	33, 635
53. Cheyenne	25, 510
54. James	20, 715
55. Kansas	59, 710
56. Little Sioux and Floyd	5, 801
57. Missouri (direct—Cheyenne River to Missouri State line)	31, 428
58. Niobrara	11, 875
Platte	89, 877
59. Platte (main)	65, 832
60. South Fork Platte	24, 045
61. Sioux	8, 212
62. White (S. Dak.)	10, 209
63. Gasconade	3, 540
64. Grand	7, 831
66. Missouri (direct, in Missouri)	17, 232
67. Osage	14, 967
Arkansas—White River:	
Arkansas	160, 664
68. Arkansas (direct)	95, 367
69. Canadian	47, 552
70. Cimarron	17, 745
71. White	27, 678
Red River—Ouachita:	
72. Ouachita	18, 643
73. Red	69, 548
SUMMARY BY MAJOR BASINS	
Ohio	203, 782
Upper Mississippi	186, 853
Lower Mississippi	52, 688
Missouri	511, 636
Arkansas-White	188, 342
Red-Ouachita	88, 191
Total	1, 231, 492

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[1] Based on planimetric measurements of United States Geological Survey maps applied to the actual surveyed areas of the States. Canadian drainage of 12,934 square miles in the Missouri Basin is not included.

[2] The drainage of the Mississippi River proper, excluding the Ohio, Missouri, Arkansas, and Red River Basins, is divided at Cairo, Ill., into upper Mississippi and lower Mississippi.

[3] Includes 5,441 square miles of indeterminate drainage such as the Atchafalaya River and other interconnected waterways in southern Louisiana.

For a proper understanding of the protective influence of the forests of the Mississippi River drainage, their relationship to floods, and their possibilities and potentialities as factors in stream-flow regulation, due consideration must be given to certain well-recognized characteristics of running water and the relationship which forests bear[1] to soil and water conservation. It is commonly stated as a law of physics that the erosive or abrading power of a stream varies as the square of its velocity. For example, if the velocity of a stream is increased 10 times, its erosive power is increased 100 times. It is also commonly stated as an immutable law that the transporting power of water varies as the sixth power of its velocity. For example, if the velocity of a stream is increased ten times, its transporting power is increased 1,000,000 times. Le Conte determined by experimentation that a current having a velocity of 2 miles an hour will move in its channel fragments of stone the size of a hen's egg, weighing about 3 ounces. From this he calculated that a current with a velocity of 20 miles an hour will carry bowlders weighing 100 tons. This is doubtless movement along the bottom of the channel.

It is the understanding of the writer that such so-called "laws" are, owing to certain variable influencing factors, mutable, although the examples cited of the comparative transporting power of river currents furnish a fair criterion of probable results.

FORESTS IN RELATION TO EROSION AND STREAM FLOW

It does not require demonstration or the introduction of scientific data to sustain the self-evident fact that water falling on steep lands tends to run off rapidly. The examples just cited show that erosion is tremendously increased by rapidity of run-off. It follows that for any given type of soil the steepest lands are most subject to erosion. Therefore it is upon steep rough lands that forests as an erosion-preventive factor are most important.

The forest breaks the impact of rainfall and retards the hasty run-off in the following way: (1), its canopy of leaves or needles, with supporting twigs, branches, and trunks, catches the first impact of precipitation and absorbs the first shock of its fall. Instead of beating directly upon the earth the raindrops are shattered and either evaporate or settle slowly in the form of mist, or reassemble and trickle down the trunk and branches, or drip to the ground. The surface of the forest floor frequently has an understory of young growth or shrubs, vines, and other vegetation which may again break the impact of fall. Under all these, at least in the typical virgin forest of the Temperate Zone, is usually an accumulation of twigs, leaves, needles, moss, and other vegetative growth forming an absorptive layer or carpet of humus often 6 inches or more in depth. Lying as it does, shielded from the wind and sun, this deposit of humus is protected from rapid surface evaporation, while affording most favorable under-surface conditions for the percolation of moisture into the soil.

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[1] Le Conte, Joseph. ELEMENTS OF GEOLOGY. Ed. 5. 667 p. illus. N. Y. 1903. Page 11, "Law of variation of erosive power.—The erosive power of water, or the power of overcoming cohesion, varies as the square of the velocity of the current." Pages 19–20, "By mathematical analysis the law is determined. That is, the transporting power of a current or the weight of the largest fragment it can carry varies as the sixth power of the velocity."

Gibson, A. H. HYDRAULICS AND ITS APPLICATION. Ed. 3. 801 p. illus. N. Y. 1905. Page 322, "While the erosive power of water varies as the square of its velocity. its transporting power, or the power to move bowlders, etc., which may lie in its path, varies approximately as v^6."

Gillert, G. K. THE TRANSPORTATION OF DÉBRIS BY RUNNING WATER. U. S. Geological Survey. Professional Paper No. 86. 263 p. illus. 1914. For a careful study, having for its purpose the empirical determination of the relation which the load of solids swept along the bed of a river bears to its velocity and other important factors of control, the reader is referred to this professional paper.

This layer of humus varies quantitatively and qualitatively according to type, location, and use. Qualitatively the humus from the conifers is more effective as a moisture absorbent than that from hardwoods. Quantitatively it is greatest in the spruce-balsam-white cedar-hemlock type of forest prevalent at the higher elevations or in northern forests and smallest in hardwood regions of the South, where the practice of burning the woods annually is prevalent and where decomposition of vegetable litter is most rapid and complete. Under favorable conditions the layer of humus in a well-managed, well-protected forest of the spruce-balsam-white cedar-hemlock type may be as much as 6 inches deep. Varying with the type of forest, the age class of the stand, the quality and kind of site, and the degree of protection and management, the depth of the humus will shade down from 6 inches to the comparatively small accumulation of a single season, which becomes nil immediately following a fire.

Under ordinary rainfall conditions this humus is capable of absorbing and holding a considerable quantity of water for evaporation, percolation, or transpiration. The amount of moisture thus actually absorbed varies; but a quarter of an inch in depth of rainfall for each inch of depth of humus or leaf litter is known to be conservative. This ratio has been used in all calculations in this report unless otherwise specified. In addition to the moisture absorbed the forest retards or holds in temporary restraint an amount of water often many times as great as the volume actually absorbed. The process of absorption itself is not instantaneous. The forest floor does not expend its full absorptive influence on the first brief shower, but the process continues over a considerable period. Even in entire immersion about 24 hours are required to complete saturation, and under rainfall conditions absorption continues for 48 hours.

While moisture is being absorbed by the mat of humus, the forest-crown cover and forest litter also hold back or retard the run-off of water not actually absorbed. Through such a combination of influences a forest having a good crown cover and a good blanket of humus can be relied upon to absorb and retain for later and more gradual and beneficial transmission a very great part of even an unusually heavy rainfall. Instances are recorded in which a forest with deep humus or leaf litter did not give off any water in the form of surplus run-off even on the steepest slopes after a rainfall of 2.4 to 2.8 inches. This, however, is beyond what can ordinarily be relied upon.

During an extended period of rainfall the quantity of water diverted from run-off by being absorbed by the mat of humus is materially supplemented by the amount of evaporation, percolation, and transpiration taking place during the same period. In addition the forest operates much like a check dam through retarding run-off by mechanical obstruction. The rainfall which is not at once absorbed or permanently impounded sinks into a tangled mass of accumulated vegetation, fills up its interstices, and slowly searches out through a maze of moss, needles, leaves, twigs, and other vegetative growth, the path of least resistance down the slope. In this way rainfall, which would otherwise reach the nearest brook in a few hours, may be delayed for days or even weeks, may finally reappear in some spring, or may be taken up by some plant and again transmitted to the atmosphere without ever contributing to stream flow.

The forest, its understory of brush, and the blanket covering of humus not only break the impact of precipitation and hold in temporary suspension a considerable volume of water, but their combined influence tends to make the underlying soil and subsoil more receptive to percolation. The soil is loosened by the roots and shielded by brush and trees from being backed by the sun and packed by the tramping of stock. Accretions of humus in the soil itself also increase the permeability and water-retaining capacity of the soil. The mulch covering also keeps the soil moist, so that the forces of absorption as well as gravitation may operate most effectively in helping to transmit to the underlying soil the excess moisture held in temporary captivity.

The forest, the brush, and the humus layer also tend to conserve precipitation in the form of snowfall by protecting the surface of the soil from freezing. Rain falling on ground already solidly frozen, or water from melting snow on frozen ground, runs off as though from a tin roof. On the other hand, even in midwinter after the ground in the open is frozen solidly, moisture from melting snow or rain can usually find its way through open spaces of the coarse top cover of forest litter into the protected layers below where it can be finally taken up by the soil.

The presence of forest cover on a given watershed may under certain conditions increase the run-off from some limited area during the spring flood period. This can happen when an unseasonably warm heavy rain encounters a winter's snow accumulation. There is, of course, a limit to the capacity of forest cover to retain moisture and retard run-off. When this limit is reached a high-water stage follows. Had the forest been cleared away and the bare soil exposed to frost, wind, and sun, most of the winter's snowfall would have been dissipated and the freshet limited in volume largely to the immediate rainfall, little if any of which would have been retained by the frozen ground. The resulting flood, while much more flashy than from a forested watershed, might not reach even as high a stage and would be of very brief duration. However, an increase in flood flow caused by forest protection is the rare exception, and over a large area would be offset by beneficial results from other drainage units. The general tendency of the forest cover is to ameliorate freshet condition, and over any large area the general tendency always prevails—the peak of the flood is not so quickly reached; the run-off is spread over a longer period of time; erosion is reduced; and damage by silting and washing is correspondingly lessened.

In conformity with the known conduct of running streams as stated in the opening paragraph of this section, forests reduce the eroding and transporting power of water by reducing the rapidity of run-off. In addition they are a direct physical obstacle to erosion because they have large, strong, well-anchored roots which hold soil, subsoil, and rocks firmly in place. A forest with a good understory of brush and a deep layer of humus is undoubtedly the best conservator of soil. Not only is the loss held to the negligible quantity removed by percolation, but actual additions of fertile material are made.

This factor of erosion is exceedingly important in flood-control work. Zon called attention to this fact in the final report of the National Waterways Commission, page 246, saying:

> Erosion has a bearing on the height of flood water in the river, since sediment carried by the rivers and the coarser detritus brought down by mountain streams often increases stream volume to such an extent that the height of the water is raised far beyond the point it would reach if it came free of detritus and sediment.

Not only does the presence of sand and gravel in the water increase the volume of the flood and raise its height, but in addition such abrasive material furnishes teeth to the freshet and enables it to tear up the earth, wear away embankments, and carry off accumulations of soil and other material otherwise safe from the ordinary attacks of flood waters. Erosion fattens as it feeds. Its progress is accelerated by its spoils of victory. The first few cubic yards of sand that enable the stream to wear away the protecting covering of sod from an exposed embankment may expose a thousand cubic yards of similar material to easy capture by the flood waters that follow.

The terrific power of mountain freshets has been pointed out by the famous French engineer Demontsey, who found that one such torrent brought down, after one storm, in 85,000 cubic yards of water, over 221,000 yards of detritus, or more than two and one-half times its own water volume. Those who witnessed the havoc wrought in Pueblo, Colo., by the flood at the headwaters of the Arkansas River, realize the destructive power of liquid mud. The Mississippi River in full-flood flow fortunately does not, even remotely, approach the speed of a mountain torrent. It would not, therefore, be capable of bearing so great a percentage of silt as a swifter stream. It is regretted that this study failed to unearth any reliable figures of recent date on silt content. Figures giving averages over long periods and for varying conditions of flow are obviously no index to actual silt content at flood crest, which is the critical point. Available data seem to indicate that the waters of the Missouri River at full-flood stage may contain as much as 3 per cent foreign matter. No estimate is attempted as to the probable silt content of the recent Mississippi flood at crest. This much, however, is certain—the country would be much richer and much better off if the eroded soil, the amount of which is known to have been great in the aggregate though it may not have made up a large percentage of the flood content, had remained in place undisturbed.

Forests are not the only safeguards against erosion. Any vegetative cover has a tendency to retard run-off and check erosion. A good brush cover or a bluegrass sod is very much better than an open stand of timber which has been heavily grazed or through which a fire has recently run. However, the combination of trees, undergrowth, and forest litter which is secured under adequate fire protection and forest management, is best for critical areas—that is, areas which owing to natural features are in danger of extensive washing. The canopy is most complete, the humus protection most thorough, and the roots strongest. It is always recommended for permanent protection purposes rather than brush or vines, for the reason that it is of value not only as a conserver of soil but for its wood crop. Tree planting to prevent erosion or for water conservation is, of course, not recommended for fields which can be profitably plowed and cropped without destructive soil washing. Nor are forests recommended for the more moderate slopes with soil which permits the establishment of a good grass cover sufficient to prevent destructive erosion and where the economic value of such cover equals or exceeds that of the forest. A good grass cover, where it can be secured and maintained, is an excellent safeguard against erosion except on the steepest slopes. As a factor in water storage or regulation, however, it does not compare with a well-managed forest.

The question of whether or not total run-off is increased or diminished by the presence of forests is one which does not admit of a categorical answer. The character of soil, the gradient, and the time, duration, quantity, and form of precipitation, as well as the character of the cover, all enter into the equation. Obviously, the ratio of total run-off to precipitation will be greatest where the slope is steepest, the soil most impervious, and vegetation most scanty. In such a case the maximum run-off occurs at once.

Usually immediate run-off is not desirable. Ideal conditions are usually found in regularity of flow, regularity at least during the period of beneficial use and sufficient to avoid an embarrassing surplus. In some cases, such as on a watershed which is a source of water supply for irrigation, power, or domestic use, the maximum sustained volume of run-off is desirable—the greater the supply the larger the acreage irrigated, the greater the power development, or the more generous the domestic supply.

Trees consume water. A rapidly growing forest may during the year consume and transmit into the air a volume of water equivalent in depth to 12 inches over its entire area. On rocky slopes, upon which through generations the forest has spread its carpet of humus to hold in its store of moisture and to help secrete water in crevices where it may be reached by the searching tree roots and used in plant growth, the forest obviously uses moisture which otherwise would have contributed to immediate run-off. But this water is only used; not destroyed. In the atmosphere it is again available for precipitation.

The flood problem is measured by the volume of run-off. Only a part of the total precipitation on any watershed ever appears as run-off. Necessarily that part of precipitation which passes into the atmosphere either by evaporation or transpiration can not appear in stream-flow measurements without again being deposited in some form of precipitation. On the other hand that part which passes into the soil as percolation must eventually appear as run-off unless evaporated or taken up in plant growth.

In the study of the relation of forests to stream flow, an important fact to keep in mind is the wide difference between the total precipitation and total run-off of any watershed. Also the fact that the ratio of the latter to the former varies widely for different watersheds. Something very important happens after the water reaches the earth but before it reaches the river. This "something" is the result of the working of three natural phenomena, transpiration, percolation, and evaporation. The two first do not greatly influence the volume of water after it once reaches a stream in the form of run-off, but the last continues its pursuit of moisture even to the sea itself. Transpiration and percolation are greatly stimulated by plant growth. This applies to forests, particularly as to percolation. Forests retard evaporation from the soil under certain conditions, but this is more than offset, so far as immediate run-off is concerned, by transpiration and percolation.

If the value of forests as stream-flow regulators and flood-preventive factors were determined by the ratio of their water-storage capacity to the total annual precipitation, such value would be relatively very small. However, such a comparison does not give a rational basis of measurement. Floods are created only by actual run-off. Therefore, the ratio of storage to run-off is a better index of flood-prevention service. [It seems desirable to illustrate the importance of this point by calling attention, out of its otherwise natural order, to the fact that of the total precipitation falling annually on the 511,636 square miles of the Missouri River watershed only 10 or 15 per cent (authorities differ, but 15 per cent is probably the better figure) ever reaches the Mississippi. The other 85 or 90 per cent is transmitted to the atmosphere by transpiration or evaporation, minus such minor quantities as may possibly be retained by some chemical process or combination.]

It is this remaining percentage which appears as run-off that contributes to the flood problem, and it is this remnant of the total for each watershed that may be in part regulated or controlled by well-managed protection forests. The ratio of run-off to precipitation is much larger for the other major basins of the Mississippi system than for the Missouri (primarily because both are higher—the spread between the two does not vary so much under similar climatic conditions), but in every case evaporation and transpiration are important factors in disposing of the total supply of water. The average run-off for the various parts of the Mississippi Valley region is shown graphically by Figure 3.

The wide difference between total precipitation and total run-off from the Missouri watershed is extremely interesting. Since that watershed is neither a lake which is increasing in size nor a shrinking desert, it must be that the 10 or 15 per cent of precipitation which the river carries in annual run-off balances the watershed's moisture account with outside sources. This fact, together with the known fact that plant life draws from the soil and returns to the atmosphere for reprecipitation considerable quantities of moisture which would otherwise have contributed directly to stream flow, suggests the possibility of increasing precipitation by encouraging vegetative growth. By irrigation, which means the recapture of moisture from run-off and its return to the soil for redispersion through evaporation, transpiration, and percolation, water may be used repeatedly. It is indestructible. By such methods of recapture and use over a period of years the water capital of a region may be greatly increased. These possibilities and their climatic consequences open a field of speculation which, however attractive, is beyond the scope of this circular.

PROTECTION FORESTS, A PUBLIC NECESSITY

The influence of forests in retarding run-off and thus diminishing the destructive power of floods, and the value of forests in binding soils and preventing erosion have resulted in many forest areas in civilized nations being established as protection forests and placed under public control. These are largely in mountainous regions where, by reason of the nature of soil, topography, and climate, conditions causing accelerated run-off are most critical and most apt to result from ordinary private use of the land surface.

The use to which any forest area is put has a direct bearing upon its effectiveness as a protection forest. Its protective influence may be injured by the character, extent, or method of timber cutting, by the season and intensity of grazing, or by any other kind of use. The private owner is interested in using the forest to produce revenue rather than public benefits. For this reason, public ownership has been found to be the only practicable means of securing the highest use of forests where the protective function is so important that other uses, such as grazing and timber cutting, must be subordinated to protection.

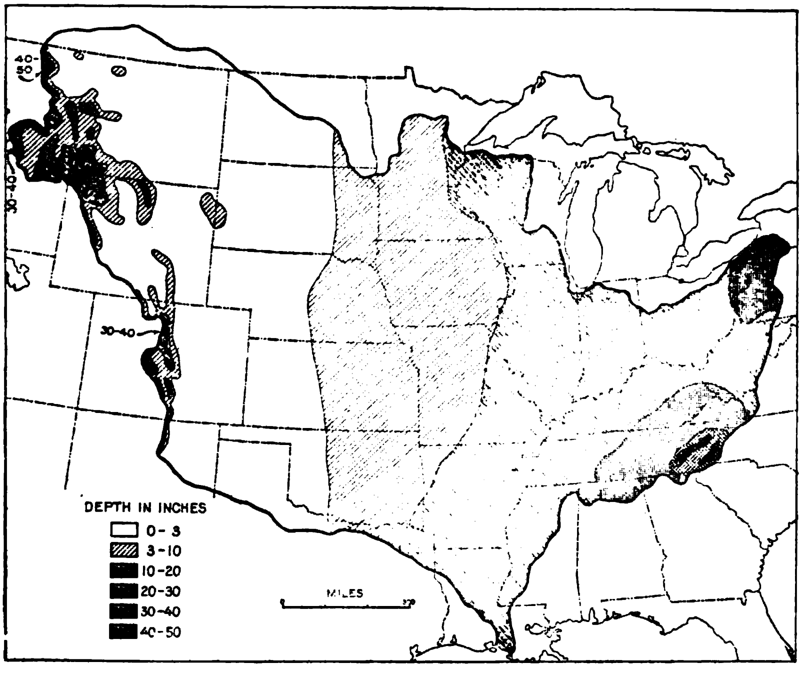

FIG. 3.—Average annual run-off

Self-preservation requires that the public step in and acquire rough broken lands where the destruction of forests or failure to maintain good forest conditions menaces interests of far-reaching importance. From the standpoint of a future national timber supply to be derived from our great commercial forests, the public interest may be safeguarded by Federal cooperation in fire control and leadership in forest management. The private incentive of revenue production will be served by securing the maximum productivity of the lands. Thus far self-interest and public interest travel one road. But where protective values are outstanding, as they are in most mountainous regions, a large measure of public ownership is a public necessity.

Public ownership of nonagricultural forest land on important watersheds is the logical outcome of the free play and development of natural economic laws and forces. The private owner of forest land in steep, rough regions can not be expected to manage his property for the public benefit when that means loss of revenue or increased expense. Conversely, the owner of properties which may be injured by the misuse of such land can not safely rely upon the owner of the forest to give other lands contributory protection. Consequently, where widely scattered but important interests may be jeopardized by unwise use of land, the only fair and safe course is for the public to step in and take charge of the key property under terms and conditions fair to the original owner.

France, Germany, Switzerland, Austria, and Japan have each recognized the special function of the protection forest, and each places such areas under public control. This principle has been carried farthest in Japan, where, owing to the mountainous character of the country, it was most urgently needed. In that little nation a total of 4,534,335 acres in 353,549 parcels has been placed under public control as protection forests. Protection forests in Japan are established against soil erosion, for water supply, against sand shifting, against wind, against tides, against floods, against avalanches, against rolling stones, for fisheries, for public health, for guiding navigators, and for scenery. However, over 90 per cent of the total area comes within the first two classes.

Protection forests are also maintained by our own Government. The act of 1897 (30 Stat., 11) authorized the President to establish public forests "for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States." The same principle was recognized by the Weeks law, passed by Congress March 1, 1911 (36 Stat., 961). Under this act there had been expended by the Federal Government, under the direction of the National Forest Reservation Commission, up to June 30, 1927, a total of $14,065,260.87 in the purchase of 2,892,721 acres of forest land for the protection of navigable streams. These lands lie in the White, Allegheny, Appalachian, Ozark, and Ouachita Mountains. They are in 19 purchase units located in 13 States.

In the application of the protection-forest principle the Forest Service has proceeded upon the theory that under our form of government the duty and responsibility of establishing public forests and regulating their use should rest first upon that public agency nearest to the problem, provided that agency is directly concerned in its solution, whether city, county, State, or Nation. The Federal Government should not step in if the local governing authority nearer the problem is willing and able to meet the public need. The same principle naturally applies all the way down the line. A town organization would not give an individual protection which he is able to provide by labor with his own hands on his own lands.

This principle has been kept in mind in this study. On Figure 6 are outlined many areas which are in urgent need of being given the status of public protection forests, also areas within which it is known that there are lands which should be given such status. No attempt has been made at this time to determine the respective fields of local, State, and Federal activities in providing protection forests. As a principle of government it is considered desirable from a national standpoint for cities, counties, and States to shoulder this responsibility so far as they are able to do so without undue hardship. Along with this principle it has also been necessary to give due consideration to the fact that often the community nearest a protection forest is not so vitally concerned as others farther removed. In such cases it would be unreasonable and unjust to expect the local taxpayer to finance an activity for the primary purpose of benefiting other regions. In some cases Federal help seems to be the only reasonable solution because of large areas and heavy expense. In such cases, where the State has already signified its approval of Federal participation, prompt action by the Federal Government is recommended.

FORESTS OF THE MISSISSIPPI VALLEY

The forest area of the Mississippi Valley has undergone great changes since the advent of the white man.[2] His form of civilization has made tremendous inroads into the virgin stands which greeted the arrival of our pioneer ancestors. The first great inroad was made in the clearing of lands for cultivation in the Ohio River drainage. This activity swept through the valleys of the Ohio and its tributaries, spread out over the rich rolling uplands, and emerged on the still more inviting prairies of the North and West. So strong is habit that the rolling timbered hills of Missouri were cleared and cropped before the prairie lands of Iowa were generally brought under cultivation.

The second great drain on the virgin-forest resources of the Mississippi Basin was lumbering. This started in rafting and floating logs and other forest products down the river to New Orleans for local and foreign trade; but got its greatest impetus when the pine, spruce, and hemlock forests of Wisconsin and Minnesota were drawn upon for the settlement and development of the great interior prairie of the Middle West. Like the clearing for agriculture, lumbering spread by widening circles into every region accessible to the growing country's demand. It reached into the great hardwood regions south of the Ohio River and sought new fields in Missouri, Arkansas, eastern Texas, Louisiana, and western Mississippi.

The process of lumbering, necessary in itself as an incident to settlement, growth, and industrial development, has unfortunately been almost universally followed, if not actually accompanied, by the forest's worst enemy, fire. This has not only taken a toll in timber probably equal in volume to that removed either in lumbering or agricultural clearings, but has in addition still more vitally affected the protective value of the forests and the future timber supplies by injury to the site, impoverishment of the soil, destruction of young growth, and the prevention of forest regeneration. Even in regions where these injurious effects are most evident, forest fires are still frequently considered an incident natural to the woods.

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[2] Evidences of these changes may be seen by comparing Figs. 4 and 5.

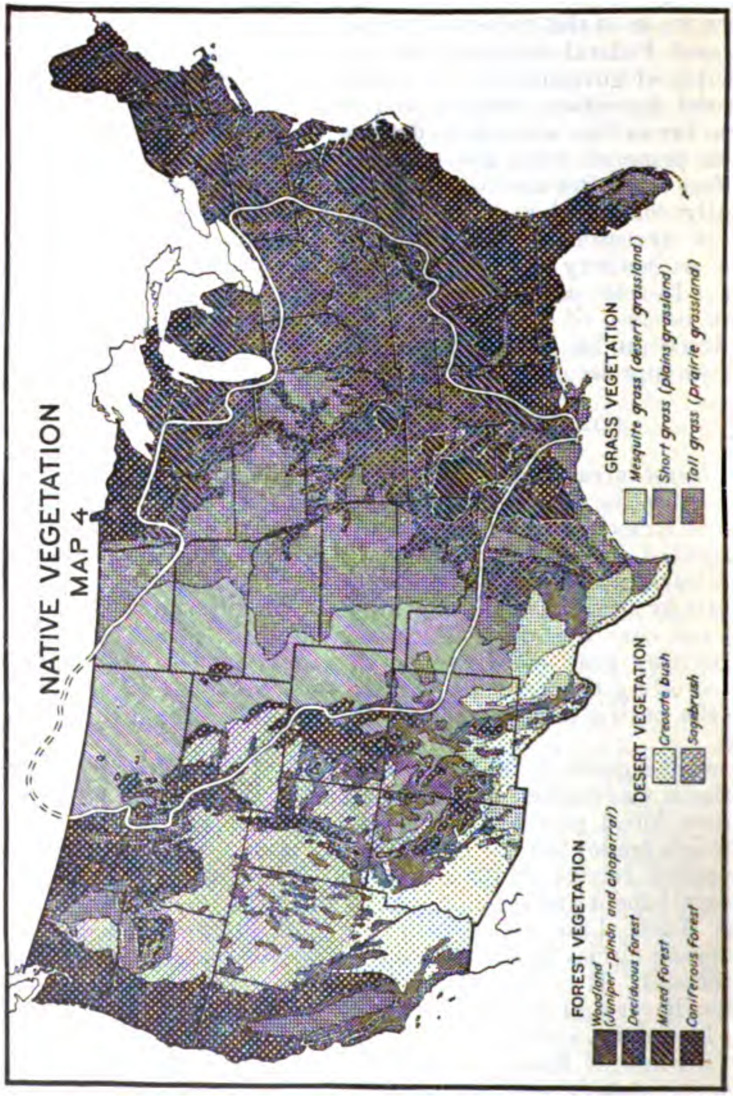
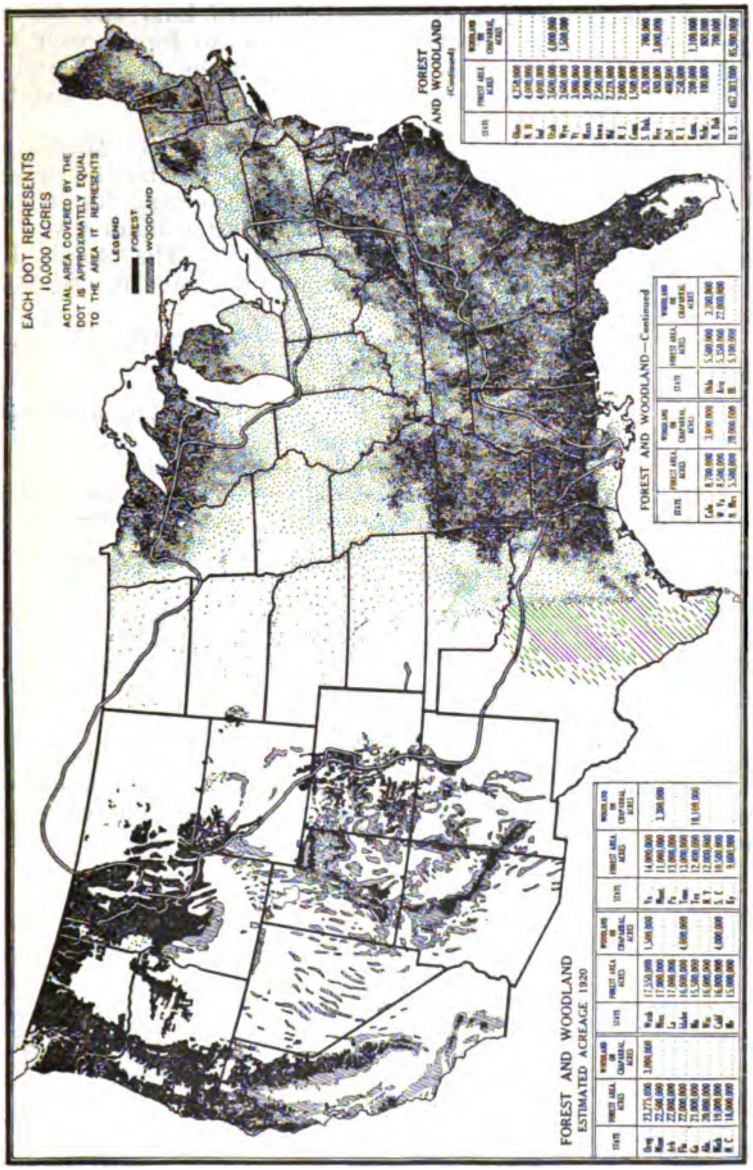


FIG. 4.—Natural vegetation

Considered entirely as a virgin area, the Mississippi Valley, even before the coming of the white man, was never what could be classified as a well-forested watershed. Not more than 40 per cent, or about 500,000 square miles, out of a total of 1,231,492 square miles, was in forests or woodlands at the time of discovery and settlement.

(Fig. 4.) The fact that floods were characteristic of the Mississippi River from time immemorial need not disturb the champion of forests as a factor tending to regulate stream flow. If that fact has


EACH DOT REPRESENTS
10,000 ACRES
ACTUAL AREA COVERED BY THE DOT IS APPROXIMATELY EQUAL TO THE AREA IT REPRESENTS
LEGEND
FOREST
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FOREST AND WOODLAND
ESTIMATED ACREAGE 1920
FOREST AND WOODLAND—Continued
FOREST AND WOODLAND (Continued)

FIG. 5.—Forest-land density

any significance it is evidence tending to associate floods with a non-forested area, since even in De Soto's time floods occurred and 60 per cent of the watershed was then without forest cover. The primary cause of that flood, as well as the flood of 1927, was unusually heavy rainfall, the effect of which the 40 per cent of forest in De Soto's time and 20 per cent of forest in our own day might somewhat ameliorate but could not prevent.

Now only 20 per cent of the basin is in forests of any kind. Even this includes a considerable acreage of denuded land and for the most part is in an unsatisfactory condition as to forest cover and forest floor. (Fig. 5.) Only a small percentage of the land in forest is in satisfactory condition for timber production or watershed protection.

Table 2 shows for each of the six major basins of the Mississippi Valley the total area, the area originally in forest, and the present forest area including farm wood lots and nonrestocking forest land, with area comparisons in percentages. The last column gives for each basin the percentage of total area deforested. The " total " line gives the same information for the Mississippi drainage as a whole.

TABLE 2.—*Forest lands of the Mississippi drainage*

Basin	Total area	Forest land (including wood lots and idle lands)		Percentage of basin areas		
		Original	Present	Original	Present	Decrease
	Square miles	*Square miles*	*Square miles*	*Per cent*	*Per cent*	*Per cent*
Ohio	203,782	186,000	68,000	91	33	58
Upper Mississippi	186,853	108,000	52,000	58	28	30
Lower Mississippi	52,688	51,000	29,000	97	55	42
Missouri	511,636	49,000	31,000	10	6	4
Arkansas—White	188,842	59,000	35,000	31	19	12
Red—Ouachita	88,191	44,000	29,000	50	33	17
Total	1,231,492	497,000	244,000	40	20	20

Table 3 gives the progress of forest destruction by basins. It shows the number of square miles of original forest cleared and devoted to farm, pasture, or other uses and the percentage of the original forest area of the basin which this area represents:

TABLE 3.—*Reduction of original forest lands*

Basin	Reductions		Basin	Reductions	
	Area	Percentage of original forest		Area	Percentage of original forest
	Square miles	*Per cent*		*Square miles*	*Per cent*
Ohio	118,000	63	Arkansas-White	24,000	41
Upper Mississippi	56,000	52	Red-Ouachita	15,000	34
Lower Mississippi	22,000	43			
Missouri	18,000	37	Total	253,000	51

The estimate of a total of 244,000 square miles of forest lands in the Mississippi Basin includes not only the commercial forests, farm woodlands, and other timberlands, but also includes about 35,000 square miles of so-called "idle" or "waste" lands. These are areas once timbered or adapted to timber growing which have been so denuded by overcutting and repeated fires that they are no longer capable of restocking themselves with valuable timber in commercial quantities. Hence they are of such low value that no one will make an effort to protect them. Lacking timber cover and continually robbed by fire of surface protection, they offer only low resistance to erosion.

About 10,000 square miles of such "idle" or "waste" land is included within the total of 115,000 square miles of woodlands belonging in farm ownership. The farm woodlands are chiefly in regions devoted primarily to agriculture.

The 129,000 square miles of forest land not in farm wood lots are in the regions where soil and topography generally are more favorable for forest growth than for farm use. Unfortunately only about 104,000 square miles are occupied by tree growth of commercial species, 25,000 square miles falling in the "idle" or "waste" class.

HOW THE WATERSHED FORESTS WERE STUDIED

It was to the 244,000 square miles of forest land remaining on the Mississippi watershed, some timbered and some idle or waste, scattered throughout the 6 major basins and 73 individual drainage units, that this study was directed. It is desirable to make clear at this point that the value of a forest in preventing erosion and regulating stream flow is not directly proportional to the volume of timber on any given area. It is influenced by other factors, such as density of cover, amount and character of undergrowth, and depth of humus accumulation. A mature forest in open stand may support a large amount of merchantable saw timber and yet because of overgrazing or repeated ground fires be so devoid of undergrowth and leaf litter as to be rated very low from a protection standpoint. On the other hand, a watershed may be very well protected by a young or scrubby growth or by thickets of inferior species by reason of the density of its canopy and the depth of litter accumulation.

Previous general studies of the forests of different regions of the United States have been made principally for the purpose of determining the value of the forests as sources of lumber or other wood products or of estimating their timber-producing possibilities. But the flood problem required a study of forest areas markedly differing from anything ever before undertaken on so large a scale. The primary purpose was to find out, if possible, to what extent our forests may be relied upon to help reduce floods and flood damage on the Mississippi.

This required at the very outset a study of the forests and forest lands of the basin to determine the extent and location of areas having important protective significance as distinguished from areas from which run-off was not materially influenced by the presence or absence of forest cover.

CRITICAL AREAS[a]

In the plan of this study an endeavor was made first to localize the source of watershed trouble so far as was found practicable, in order that effort might not be wasted, and that attention might be focused on the "critical areas" rather than diverted to others of less importance.

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[a] See Fig. 6 and Table 7.

To be of any substantial or permanent value it was evident that the classification of the areas could not be based entirely upon the immediate efficiency of each watershed. It was obviously just as important in the long run to prevent a good protection forest from being injured as to restore the efficiency of a similar area which had already been injured. Just as important and much cheaper and easier.

There were therefore placed in the "critical areas" class all forest lands found to be of such character, by reason of factors of soil, slope, and precipitation, that to prevent flashy run-off or destructive erosion the maintenance of a good forest cover was necessary as proved by the results of forest destruction on similar land. It was upon the areas so classified as "critical areas" that this study finally centered. Under this general designation of "critical areas" two general regions not falling in the class of forest lands were finally included. These are the Bad Lands and "the Breaks."

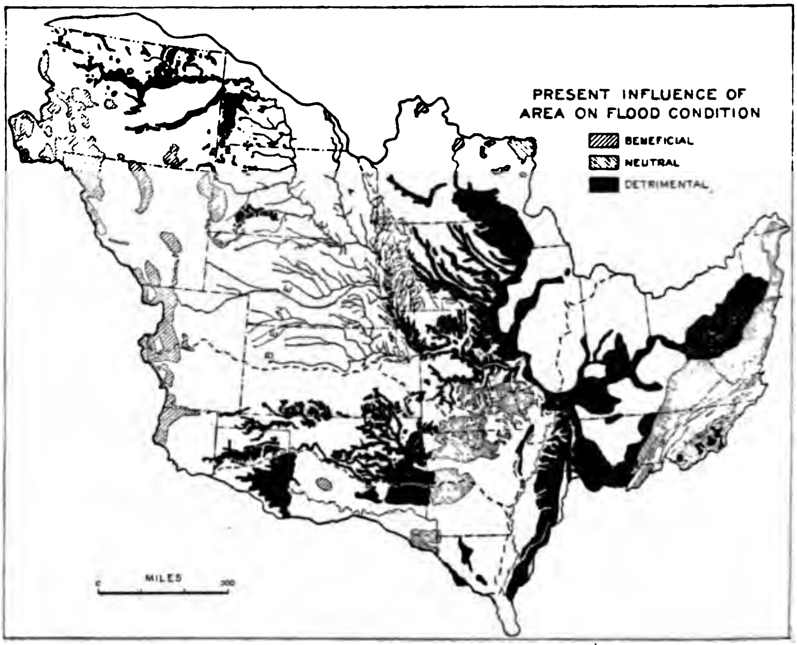

FIG. 6.—Critical erosion areas

HOW DETERMINED

The determination of "critical areas" involved the consideration of many complex and conflicting factors. While the three main factors which determined the final classification (soil characteristics, physiography, and precipitation) are relatively constant for each part of a drainage unit, they vary for different parts of the unit.

Furthermore, each factor is exceedingly complex. For example, an average precipitation of 40 inches annually in the form of an occasional torrential rain will have a very different effect from the same total amount of precipitation in many gentle rains well distributed throughout the year. Any system of measurement based upon factors so variable is obviously not infallible. At the same time it has furnished the Forest Service with a substantial background of information which, when checked by run-off conditions on the ground, is reasonably accurate. At least it gives different examiners in different regions common standards of measurement and makes comparisons possible. Faulty as this method may be, wide diversity of conditions required the adoption of some uniform method of rating watersheds in order to make possible the summations and comparisons absolutely essential to any real conception of actual conditions on such a large area.

By means of the rating system adopted Figure 6 now gives for the first time a graphic presentation of the areas where the maintenance of good forest cover is believed to have an important relationship to flood control.

The location of "critical areas" having been determined, a further classification was made according to present conditions. Those which were not the source of heavy deposits of silt or flashy run-off were classified as "beneficial." Those which had seriously deteriorated but were apparently in a static condition, if not actually improving, were classified as "neutral." Where deterioration was active the areas were classified as "detrimental."

HAS DEFORESTATION INCREASED THE SEVERITY OF MISSISSIPPI FLOODS?

It has not been possible, within the limited time available for this study, to determine quantitatively to what extent forest depletion has contributed to the Mississippi floods. It has seemed more important to determine how and to what extent forests may contribute to flood prevention. It is sometimes claimed that there has been no marked change in the Mississippi flood situation due to deforestation or any other cause. This study has not undertaken either to prove or disprove such a theory. It does, however, seem well to call attention to certain facts. (1) By the construction of dams at the outlets of certain lakes, Lake Winnibigoshish and others, reservoirs have been established at the headwaters of the Mississippi constituting what is said to be the greatest water-impounding system in the world. (2) There is now under irrigation in the Mississippi Valley, according to the 1920 census, a total of 5,005,577 acres of arid land.

The impounding capacity of the lake reservoirs at the headwaters of the Mississippi is reported to be slightly in excess of 95,000,000,000 cubic feet. A reasonable estimate of the average amount of water used in irrigating arid lands on the Mississippi watershed is 24 inches annually. The total amount of water diverted from stream flow and absorbed by the reported acreage of irrigated land each year is therefore more than 435,000,000,000 cubic feet, or more than four and one-half times the total capacity of the great reservoir system in Minnesota. Of course not all of this water is consumed by evaporation and plant growth. A considerable part eventually reappears in springs elsewhere and returns to stream flow, but such return is a gradual process. These are only two outstanding examples of the control of water in the Mississippi Valley out of hundreds that have taken place during the past 40 years. If, therefore, there has not been a marked change in the flow of the river during this period the only possible explanation seems to be that such works beneficial to the stability of stream flow have been offset by other factors of equal power, but working in a detrimental direction.

STUDY REQUIRED CONSIDERATION OF ALTERNATIVE USES OF FOREST LAND

The study of the protective influence of forests in the Mississippi Valley and of the contribution that effective forest protection, necessary reforestation, and the productive use of land for forest crops, may make to flood control, proved to the men engaged in this work that, broadly spreaking, the problem was one of the wise use of land. It was found necessary not only to study the areas which are in forests and to determine whether or not they were doing their share toward water and soil conservation, but in many cases it seemed even more necessary to study lands which, although not now in forests, should be.

It may as well be stated at this time that undoubtedly the greatest burden of silt and freshet run-off contributed to the Mississippi River comes not from forest land but from farm lands which are being unwisely used. The reports on the 6 major basins and the individual reports on the 73 drainage units uniformly testify to the general fact. Not only is the silt and run-off greater from the agricultural regions as a whole than from the forest regions—it could hardly be otherwise from a great basin only 20 per cent in area timbered—but greater in proportion to area.

Again it should be made clear that it is not the original lumbering operations which have mainly caused soil impoverishment, erosion, and floods, but the repeated fires which have usually followed such operations. Nature is a great physician. If given a reasonable opportunity she displays marvelous skill and promptness in curing many ailments. The forest on a hillside may be removed by fire or logging operations. The first year following such destruction or utilization the snowfall goes off in a torrential rush, which makes a gulley of every road, log slide or wheel track. But in a few years, at the most 5 or 6 in relatively humid regions or 15 or 20 in semiarid regions, if there have not been repeated fires, nature will have stopped destructive erosion. But, unfortunately, the curative process of nature is usually defeated by the destructive process of burning the woods. Erosion may be stopped in a few years, but it takes much longer to rebuild the mat of humus to its maximum storage capacity and restore the diminished springs to their original flow. The odds against nature are usually so great that such results can not be expected without effective fire protection and intelligent forest management.

CLASSIFICATION OF FORESTS

For the purposes of this circular, the forest lands of the Mississippi Valley have been divided into three classes based directly on ownerhip—but ownership largely as influenced by use. The three classes are as follows:

1. Commercial forests privately owned.
2. Farm woodlands and forest lands within regions where agricultural interests are generally dominant.
3. National forests and national parks and the unreserved timbered portions of the public domain.

COMMERCIAL FORESTS

Lands classed as commercial forests, which in some regions are often given the general designation "lumber woods," embrace the major lumber regions of the valley and have in the aggregate a total area of 108,000 square miles, including cut-over and waste lands similar in character and location. They are in private or corporate ownership and are the source of most of the lumber produced in the valley. Generally speaking, they are of negligible value for farm-crop production chiefly because of soil or topographic features. They are broadly grouped under the following subdivisions: 1. "Lumber woods" of Minnesota and Wisconsin; 2. Hardwood region of Ohio Basin; 3. Bottom-land hardwoods of Mississippi Delta; 4. Southern pine region of Louisiana, Mississippi, and Arkansas, with adjoining upland hardwoods.

Each of the foregoing regions will be discussed separately. One important feature common to all is the fire hazard and the injury which has resulted from the ravages of fire. Each region has its season of fire danger. In each region fire control is a major factor in forest perpetuation. Yet in each region this fact has been given little consideration by the landowner until recently unless merchantable stands of saw timber, improvements, equipment, or saw logs have been threatened.

Section 2 of the Weeks law of March 1, 1911, recognized the importance of forests from a stream-protection standpoint and authorized Federal cooperation with the States in protecting from fire the forested watersheds of navigable streams. This encouraged States and private owners in many regions to undertake systematic fire protection. The Clarke-McNary law broadened the basic act, with the result that the Federal Government is now cooperating in organized fire protection with 20 States lying wholly or partly within the Mississippi Valley.

The Clarke-McNary law was based upon the theory that fair division of the costs of protecting forest lands from destruction was 50-50 as between the private owner and the public; that one-half of the public share should be assumed by the Federal Government and one-half by the local powers, and that the work should be directed by State authority.

Under this law progress is being made in protecting the forests of the Mississippi Valley as well as elsewhere, but not as rapidly as could be wished.

On Figure 7 the area in the Mississippi watershed now covered by cooperative fire protection is shown graphically. By comparing this with Figure 6, showing the areas which are critical from a flood standpoint, it will be seen that the blanket of protection falls far short of covering the areas of fire hazard. However, the trouble lies not so much in the shortness of the protection blanket as in its thinness. The organization is far from being adequate to cope with the danger. This situation is shown in detail by Table 4, which gives for each State the area in the Mississippi drainage requiring forest protection, the estimated cost of adequate protection, and the extent to which the Federal Government is meeting its 25 per cent of such estimated cost, also the extent to which the private owners and States are meeting their 75 per cent of the estimated cost of adequate protection.

TABLE 4.—*Fire-control cooperation, under section 2 of Clark-McNary law, with States and private owners in the Mississippi Valley*[1]

State	Approximate area of State and private forest land in need of protection	Estimated cost of protection	Federal share of cost, 25 per cent of whole	Federal funds available fiscal year 1928	Extent to which Federal Government is meeting responsibility	State funds available fiscal year 1928	State share of cost, 75 per cent of whole	Extent to which States are meeting responsibility
	Acres	*Dollars*	*Dollars*	*Dollars*	*Per cent*	*Dollars*	*Dollars*	*Per cent*
Alabama	2,000,000	23,140	5,785	1,968	34.0	2,282	17,355	13.1
Georgia	341,400	5,500	1,375	430	31.3	593	4,125	14.4
Kentucky	9,000,000	225,000	56,250	14,404	25.6	14,404	168,750	8.5
Louisiana	8,510,000	203,700	50,925	19,400	38.1	57,036	152,775	37.3
Maryland	50,000	2,856	714	280	39.2	1,400	2,142	65.4
Minnesota	9,000,000	132,980	33,245	21,715	65.3	102,059	99,735	102.3
Mississippi	4,000,000	90,000	22,500	7,910	35.2	13,760	67,500	20.4
Missouri	10,000,000	260,000	65,000	11,000	16.9	11,000	195,000	5.6
Montana	1,000,000	17,680	4,420	1,685	38.1	5,150	13,260	38.8
New York	400,000	27,000	6,750	2,890	42.8	14,855	20,250	73.4
North Carolina	600,000	16,000	4,000	1,368	34.2	1,700	12,000	14.2
Ohio	1,100,000	27,800	6,950	2,913	41.9	14,623	20,850	70.1
Oklahoma	5,000,000	160,000	40,000	13,710	34.3	14,670	120,000	12.2
Pennsylvania	3,600,000	104,960	26,240	10,035	38.2	58,100	78,720	73.8
South Dakota	50,000	1,500	375	375	100.0	7,235	1,125	643.1
Tennessee	10,000,000	250,000	62,500	21,250	34.0	21,250	187,500	11.3
Texas	300,000	5,588	1,397	477	34.1	496	4,191	11.8
Virginia	1,000,000	30,072	7,518	2,560	34.0	2,560	22,554	11.4
West Virginia	5,850,000	140,500	35,125	13,290	37.8	44,388	105,375	42.1
Wisconsin	12,000,000	232,400	58,100	23,100	39.8	86,856	174,300	49.8
Total	83,861,400	1,956,676	489,169	170,760	34.9	474,417	1,467,507	32.3

[1] Total funds available, fiscal year 1928, $645,177; additional sum required to provide adequate protection $1,311,499 a year, of which the United States Government should provide an additional $318,409 and the private owners and States should provide an additional $993,090.

It will be seen from Table 4 that at the present time the protection given the forests of the Mississippi Valley is about one-third adequate. Obviously we can not expect these forests to give satisfactory protection from erosion to the critical areas and from flood to the lowlands unless the forests themselves are adequately protected. After the study which Congress has already given this part of the forest problem, it does not appear necessary to extend the discussion in this circular further than to say that the reports on each individual drainage unit constituting the great basin of the Mississippi indicate that forest fires everywhere play a large part in forest depletion. Even where the standing timber is not consumed or killed, repeated fires are preventing the accumulation of normal undergrowth, small trees, and depth of humus. Fires are in every region reducing the storage capacity of the privately owned commercial forests, and freshet run-off accompanied by unnecessary erosion results. No matter what other steps are proposed, effective fire control is needed in all the forest regions on the Mississippi watershed. It is the first step in developing the possibilities of forests for flood prevention.

LUMBER WOODS OF MINNESOTA AND OTHER LAKE STATES

The lumber woods of Minnesota and the other Lake States is a region of conifers or mixed conifers and northern hardwoods, such as beech, birch, and maple. Its southern boundary runs from east to west as follows: From Kilburn northwest to Black River Falls, thence to Eau Claire and St. Croix Falls, Wis., or Taylors Falls, Minn., thence west to Rush City, thence to Milaca, thence to Little Falls and Wadena, and thence north to Itasca Lake.

This was the region of the great northern white pine and Norway pine forests on the sandy plains. The swamps contained black spruce, northern white cedar, tamarack, and balsam fir. Only a negligible amount of virgin forest remains. Fortunately the watershed problem in this region is not generally critical. Much of the area has sandy soil which, in this comparatively level country, absorbs precipitation promptly and is not subject to erosion. In addition, swamps and innumerable lakes combine to make the whole region a natural storage reservoir. This has been supplemented by a system of six great reservoirs constructed and operated by the United States Engineer Corps. The total capacity of this system, which embraces Lakes Winnibigoshish, Leech, Pokegama, Pine Sandy, and Gull, is 95,268,100,000 cubic feet.

Despite the fact that these lands are in an exceedingly unsatisfactory condition from the standpoint of timber production, they are not generally a menace to the watershed. The condition of the soil, the topography, and the numerous lakes which act as storage reservoirs and settling basins, all combine to furnish a very regular flow of water unusually free from sediment. This statement can be made for the Mississippi River as a whole as far south as the outlet of Lake Pepin, which acts at its last general settling basin.

One exception is noted at the head of the Wisconsin River where, owing to the character of topography, nature of soils, and climate, the preservation of forest cover is of public importance. An examination of this general region has been made by the secretary of the National Forest Reservation Commission in furtherance of the Weeks law, and an area of about 250,000 acres of rough land with innumerable lakes has been found to have great possibilities as a protection forest under public ownership or control. About 100,000 acres of the area lie on the Mississippi drainage and could probably be acquired at an average price of about $2.50 per acre. This area appears to be the one portion of the lumber-woods region of the Lake States the control of which for forestry purposes would have any material bearing on the flood situation.

It may, and undoubtedly will, be necessary to establish other public forests in this part of the Mississippi Valley for fire control and wood-production purposes, since a great extent of excellent forest land is needlessly lying in waste. This may involve the problem of managing swamp lands for forest and game purposes, or may, for example, provide for the enlargement of the present Minnesota National Forest. Such lands, important as their proper use may be from the viewpoint of conserving economic resources, do not appear to have sufficient bearing upon flood control to warrant consideration in this study.[4]

BOTTOM-LAND HARDWOODS

With the exception of the area of sandy plains and innumerable lakes of the "lumber woods" region of the Lake States, no other considerable body of forest land in the Mississippi Valley presents

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[4] Data made available in the report of Nov. 28, 1927, issued by the Mississippi River Commission since the foregoing paragraph was written, seem to indicate that the presence and character of forests even in this region have a much greater influence on run-off than is usually supposed. The report states that below Pokegama Lake, near the headwaters of the Mississippi River, and just above Grand Rapids, Minn., a reservoir dam was built across the Mississippi River more than 40 years ago (1884). The run-off from the entire watershed above that point is collected in this and two other reservoirs in the same basin. Aside from evaporation, and allowing for change in the amount of stored water, the entire run-off of this watershed has passed through Pokegama Dam. Its discharge has been measured accurately for 42 years and checked from the discharges of the two reservoirs above; the rainfall has been measured daily at the three dams for the same period, and the area of the watershed has been carefully determined as 3,265 square miles. Of this area, 584 square miles are lake surface and 2,681 square miles are land surface.

The report of the Mississippi River Commission (p. 74) says: "The region is one where normal rainfall and normal evaporation are about equal. Therefore the rainfall over the lake surface is lost by evaporation and the measured run-off is that of the 2,681 square miles of land. Thus we have with great accuracy the three features necessary to a complete determination of the relation of run-off to rainfall—area of watershed, rainfall, and run-off. In the 42 years mentioned the basin has passed through all phases, from virgin forest, through the logging period, and forward to agriculture or backward to a growth of scrub and young timber—autoforestation. Because of the fact that much of this area is Indian reservation, and most of it poor agricultural land, it has largely gone backward rather than forward."

The report of the Mississippi River Commission furnishes the gist of the 42 years' observations, divided into six seven-year periods, in the form of a table, which is given below, supplemented by a final column furnished by the author of this circular showing the number of inches of rainfall retained by the watershed and the number of inches of run-off.

Seven-year periods	Average annual rainfall		Run-off	Run-off in percentage of rainfall	Water	
					Run-off	Retained
	Inches	*Millions of cubic feet*	*Millions of cubic feet*		*Inches*	*Inches*
1885 to 1891	25.318	1,103,856	222,745	20.18	5.108	20.21
1892 to 1898	26.417	1,151,774	261,460	22.70	5.997	20.42
1899 to 1905	29.687	1,294,967	442,545	34.17	10.147	19.54
1906 to 1912	24.446	1,066,379	252,565	23.68	5.786	18.66
1913 to 1919	25.420	1,108,202	284,002	25.63	6.510	18.90
1920 to 1926	21.583	941,078	148,933	15.83	3.413	18.17

The first three periods cover the time from virgin forest to practically complete deforestation, as far as pine timber, the principal native growth, is concerned, and the last three periods cover a gradual relapse to scrub with the growth of young timber (autoforestation), and some advancement to farms. It will be seen from the above figures that the percentage of run-off increased as deforestation advanced and decreased again as a growth of scrub and young timber gained foothold. More marked, however, is the influence of the forest shown by the figures in the last column, which indicate the number of inches of rainfall actually retained by the land. The average for the first two seven-year periods, which included the virgin-timber epoch, is 1.775 inches a year greater than the average for the last two seven-year periods. An absolute reduction in run-off of this amount applied to a large area would obviously have tremendous influence upon the action of the streams affected. In this particular case, however, the increase in run-off during the period of deforestation and the reduction in run-off as the forest is restored may be accounted for by a marked increase in average precipitation during the first epoch and a marked decrease during the last. The Mississippi River Commission, misunderstanding the theory of the application of the forest to the regulation of stream flow, compared these data with similar data from another watershed which was farmed extensively, and reached the conclusion "that farm lands reduce run-off more than do cut-over lands," a conclusion which is absolutely sound but is of little more than academic interest, since lands valuable for farming are not usually considered for forest purposes. The further conclusion of the commission "that cut-over lands have no greater run-off than do virgin forests" is a misinterpretation of the forest-protective influence shown by the above table, since the proper measure of effectiveness in a given condition is the number of inches of water actually retained by the watershed rather than the percentage of run-off.

so simple a problem from a flood-control standpoint as the timbered bottom lands of the Mississippi Delta.

This type of forest, from Cape Girardeau to the Gulf, can be said generally to be the forest type originally common to the lands now subject to overflow or in danger of inundation by floods. Such forests are of service in binding the soil along the stream banks and in checking destructive washing. They can not be said to increase or lessen flood volume materially, although they consume a great amount of moisture in the process of growth and thereby produce valuable material on lands which in an undrained condition were otherwise unproductive. Forests may even be undesirable when they occupy portions of the flood plain where the distance between the levees is narrow and rapidity of current is desirable, since they tend to retard stream flow. On the other hand, bottom land forests may be the best crop to raise on overflow lands where there is room for the stream to spread out. Since the forests tend to retard the flow, this aids the water to deposit its excess load of silt, thereby reducing its power to do damage as it travels on down the river.

The Delta hardwoods grow with unusual rapidity owing to the rich soil, heavy rainfall, and long growing season. Where the soils are properly drained and are assured protection from overflow such lands are of course too valuable to devote to forests. However, where the lands are poorly drained or where overflow is periodic, and particularly where the soil may be endangered either by being washed away or buried in a covering of river sand, trees may prove to be the most valuable crop. If, therefore, it should be found necessary for the public to acquire bottom lands for overflow or reservoir purposes, consideration should be given to their utilization as public forests, whereby their earning powers for wood production would be used as a means of lightening the burden placed upon the public by flood-prevention expenditures.

Above the Delta the bottom-land hardwood type continues to a considerable distance. However, in its northern extension it is chiefly stream marginal in character and falls in the general classification of farm woodlands. The necessity of exercising care in the management of such lands will be discussed in dealing with forest lands of that class.

UPLAND HARDWOODS OF OHIO RIVER BASIN

The entire Ohio River drainage, with the exception of about 17,000 square miles of prairie lands in Indiana and Illinois, was originally practically one vast forest, largely of hardwoods. There were limited amounts of northern white pine and hemlock in the upper Allegheny region in Pennsylvania and New York, and minor tracts in Ohio. Only a few remnants of these conifers are left. There were also limited forests of spruce and hemlock in the mountainous parts of West Virginia, North Carolina, and Tennessee, some of which continue unchanged as to type, although largely cut over.

In no other drainage basin of the Mississippi has human occupancy changed forest conditions to so great an extent as in the Ohio Basin. Of a total area of 203,782 square miles, of which 186,000 square miles was timbered, only about 68,000 square miles of forest or forest land remains. This is broadly described as falling into two classes: (1)

Comparatively contiguous bodies of timber in the mountainous and plateau regions; (2) farm wood lots, which are isolated small bodies of timber scattered through the better agricultural sections, and fringes of hardwood species generally found on the bluffs and banks of stream courses bordering agricultural lands.

The plateau and mountain forests are the only areas in the Ohio Basin requiring special discussion, since the farm wood lot and stream marginal woods in the regions essentially agricultural will be considered as a general class for all major basins of the Mississippi.

Proper care of forest land is particularly desirable in this basin, because it has a very high run-off for its area as compared with the other major basins. There is a striking contrast between its estimated average run-off of 300,000 second feet from 203,782 square miles and the 100,000 second feet from 511,636 square miles in the Missouri River Basin.

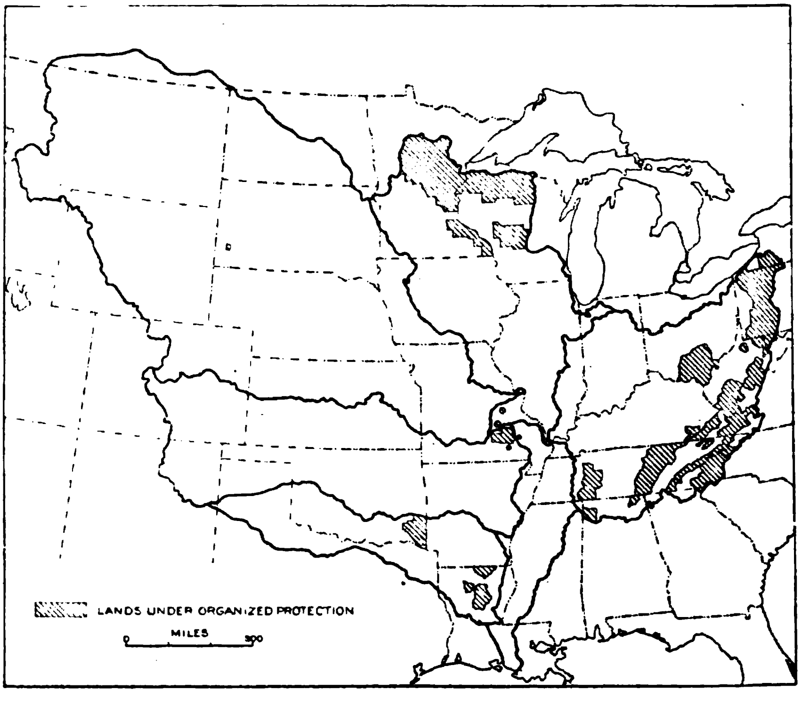

FIG. 7.—Area protected against forest fire (under Clarke-McNary law)

By a glance at Figure 5, showing the distribution and density of forest lands in the Mississippi Valley, one sees that these plateau and mountain forests are two almost continuous bodies of land, largely in forest, practically paralleling one another but separated by the valley of the Tennessee River. The one lying to the south covers the most rugged parts of the southern portion of the Appalachian Mountains. The more extensive one to the north and east is known as the Cumberland Plateau through Kentucky and Tennessee and as the Allegheny Plateau in West Virginia and Pennsylvania. A remnant of this formation having a high percentage of forest land lies in western Tennessee just east of the river of that name and quite removed from the main portion of the plateau.

In the more southerly Appalachian Mountain region the plans of the Federal Government for forest protection and stream-flow regulation have already been well crystallized, as will be seen from Figure 8. Practically all of the region, containing more than 75 per cent of forest land, is already within the boundaries of national forests created from purchased areas established by the National Forest Reservation Commission under authority of the Weeks law, or in the Smoky Mountain National Park more recently authorized by Congress. The task of completing the actual purchase of the forest lands within these units remains. The same statement holds true for the several national forests on the Allegheny Plateau farther north, and for that part of the Alabama National Forest lying within the Ohio Basin.

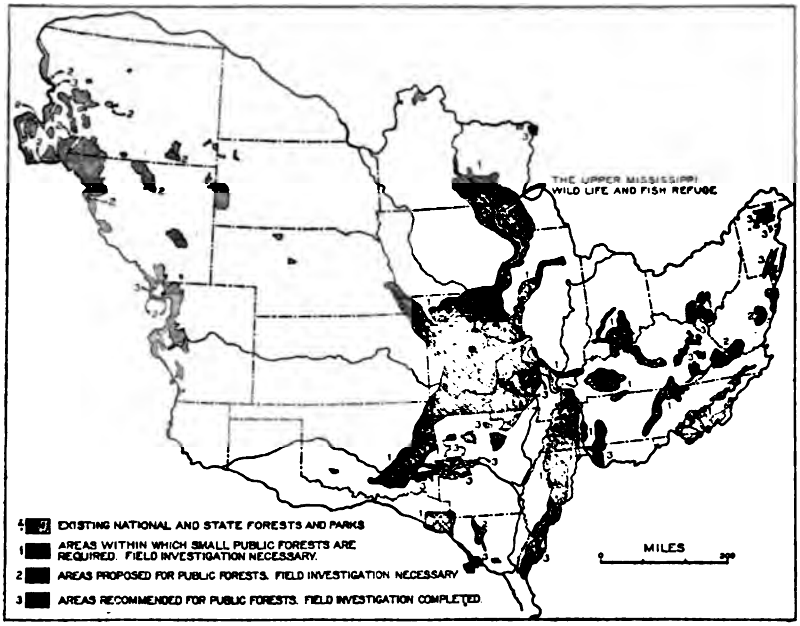
THE UPPER MISSISSIPPI WILD LIFE AND FISH REFUGE
EXISTING NATIONAL AND STATE FORESTS AND PARKS
1 AREAS WITHIN WHICH SMALL PUBLIC FORESTS ARE REQUIRED. FIELD INVESTIGATION NECESSARY.
2 AREAS PROPOSED FOR PUBLIC FORESTS. FIELD INVESTIGATION NECESSARY
3 AREAS RECOMMENDED FOR PUBLIC FORESTS. FIELD INVESTIGATION COMPLETED.
MILES
0
300

FIG. 8.—Reservations: Existing and proposed

There is still, however, a wide gap between plans and accomplishment as far as actual purchases of land in the national forests in the Ohio Basin are concerned. The total area within such forests is 3,931,476 acres, while the area of net Government land acquired is only about 700,000 acres. However, lands are steadily being offered for sale, and purchases are being made by the Government. These national forests will doubtless ultimately be carried to completion without receiving any further consideration from a flood-control standpoint.

The conditions which necessitated the establishment of public-protection forests in the main mountain range are found to exist in equal degree over a considerable extent of the plateau lying north of the Tennessee River and terminating in the Allegheny National

Forest in Pennsylvania. Within this region a number of areas have been examined by the Forest Service under the provisions of the Weeks law and found to meet the requirements of public-protection forests. These areas are shown in Figure 8, and are indicated by the numeral 3. The examiners' reports have shown that such areas are sadly in need of protection, but the funds at the disposal of the National Forest Reservation Commission have never seemed sufficient to justify a recommendation that the commission extend its program to this region. Another deterrent feature has been the fact that much of the area is underlain with coal, which necessitates limiting purchases to surface rights, with a mineral reservation and use running to the mining company. However, in other mineral regions it has been found practicable to meet this situation through a division of surface and subsurface rights, and there is every reason to feel confident this plan will prove workable here.

Three other units, shown in Figure 8 and indicated by the numeral 2, are roughly outlined areas which are reported as urgently in need of public protection-forest status. In addition, a considerable number of regions are outlined in Figure 8 and indicated by the numeral 1, within which there are areas of greater or less extent which are eroding badly and from which unnecessarily turbid and flashy run-off contributes to the general flood problem of the basin. The establishment of such areas as protection forests would be a contribution to regularity of stream flow. These regions are recommended for future consideration and examination with a view to determining the proper ultimate status of such lands.

SOUTHERN-PINE REGIONS AND ADJOINING UPLAND HARDWOODS

The Southern pine and adjoining upland types of forests are treated together as a single region, for the reason that they are found closely intermingled and allied. Their territory includes all land outside of the bottom-land hardwood type in Mississippi, Louisiana, Arkansas, the southeastern third of Oklahoma, the northeastern corner of Texas, most of the State of Missouri south of the Missouri River, and that part of Tennessee and Kentucky not drained by the Ohio. Pine predominates in the Mississippi region south of the Black River in Louisiana, and in Arkansas south of the Arkansas River. Elsewhere west of the Mississippi the two types divide the territory about evenly. East of the Mississippi and north of Black River upland hardwoods prevail, these being in reality a continuation of the vast hardwood belt extending westward from the Ohio Basin.

While forest depletion is far advanced in this region there still remains a much larger acreage of virgin timber than in any other forested region of the United States east of the Rocky Mountains. Cutting for commercial lumbering and clearing for agriculture have advanced farther as a whole in the pine type than in hardwoods. Considered separately, commercial lumbering has made greatest inroads in the pine forests and clearing for agriculture has made greatest advances in the hardwood type. This is the natural result of pine being most in demand for milling purposes and of the hardwood lands having generally richer soils than the pine lands.

Because of even topography and sandy soils, a considerable part of the pine land west of the Mississippi, like the sandy pine land of the Lake States, does not erode readily and quickly absorbs rainfall to the limit of the capacity of its soils. For this reason the presence of forest cover is not essential from the standpoint of stream-flow regulation. Consequently large parts of the forest lands as shown in Figure 5, although largely in an unsatisfactory state from the standpoint of timber production, are not shown as critical areas upon which the maintenance of good forest cover is essential to stream-flow regulation. This statement holds good for a considerable part of the pine lands of Louisiana and Arkansas. However, several areas of comparatively rough or broken lands, with prevailing steep slopes are shown in Figure 6, which are exceptions to this rule. Upon these the maintenance of the forest is necessary to prevent erosion and freshet run-off. The same condition prevails on the areas of pine lands indicated as critical in Figure 6, in Arkansas, Oklahoma, and Missouri. The establishment of the Ouachita and Ozark National Forests in Arkansas has resulted in improved conditions in that portion of the State which embraces the rougher regions. However, the problem of fire protection has proved so difficult that even now these areas can not be rated better than neutral from a watershed standpoint. If protection from fire can be made effective, these should eventually become beneficial. However, much still remains to be done before satisfactory fire control is realized. Public sentiment appears to be changing in favor of fire prevention, as against the long-standing practice of woods burning.

Lying east of the Mississippi and extending from southwestern Kentucky on the north through Tennessee, Mississippi, and Louisiana on the south, is a long, comparatively narrow area which as a flood menace and erosion problem appears to be by long odds the most serious and important of any in the Mississippi Valley. The white area adjoining it on the west, as shown in Figure 6, is bottom lands. The area shown as critical is high land. This is a region of exceedingly deep and loose soils, subject to excessive erosion. These soils are of wind-blown origin, picked up from the river-borne silt through the endless ages, and deposited by the prevailing winds from the west. The soils are deepest and conditions most critical, generally speaking, along the western rim and shade off gradually toward the east. Examples of vertical gully erosion 20, 40, and 60 feet deep, are not uncommon. One case was reported with a depth of 160 feet. This condition of deep, loose soils in a region of heavy rainfall requires a very slight slope to start destructive erosion. In one drainage unit—the Homochitto—the 1925 census shows a reduction of about 30 per cent in plowlands as compared with 1920, due largely to the enforced abandonment of eroded fields. Within this unit the secretary of the National Forest Reservation Commission has examined the two areas outlined, one of 218,000 acres and another of 420,000 acres, as shown in Figure 8, with a view to recommending purchase by the National Forest Reservation Commission. However, a portion of the eastern area is not essential to stream-flow regulation. The total of the two areas so classified is found to be 546,000 acres. The Mississippi enabling act at present limits forest-land purchases by the Federal Government to only 25,000 acres, and this should be given consideration in planning an immediate program of Federal purchases.

The urgent necessity of exercising care in handling the lands in this region of delicate balance can not be overestimated. It is important from a flood standpoint; it is important from a drainage standpoint, since the silt from these lands fills the drainage canals on the lowlands; not only is it important for the protection of the lowlands from silt and floods, but the protection of these lands is also vital to the future usefulness of the region itself. Destruction is now taking place that can never be remedied. Much of this destruction can be stopped, but it will require real effort to stop it. The entire area is, therefore, shown in Figure 6 as "detrimental" and recommended for examination with a view to determining what portions are so subject to erosion that they should be permanently kept in public forests for protection purposes. These will be the steeper, rougher lands along the western border of this general soil type.

PROTECTION FORESTS IN COMMERCIAL-TIMBER REGIONS

The largest areas in urgent need of protection forests are found in the commercial forest regions of the Appalachian, Ozark, and Ouachita Mountains, the Cumberland Plateau, a few broken areas in the southern pine regions and adjoining hardwoods, and an area at the head of the Wisconsin River. These have been referred to in the discussion of the different regions and are indicated in Figure 6.

The importance, from a national standpoint, of prompt action and the great acreage that must still be left to local initiative requires that immediate steps be taken by the Federal Goverment toward the acquisition of more protection forests in the Mississippi Basin. With the concurrence of the State authorities, and in consultation with them to avoid conflict with any State forestry programs, the Government of the United States should approve as purchase units all areas within the commercial forest regions meeting the standard requirements governing the National Forest Reservation Commission in the execution of the Weeks law. This, of course, limits immediate action to the scope and regions approved by the legislatures of the several States. With these points in view a number of areas considered in this study have been listed in a tentative program for the purchase of protection forests needed on the Mississippi watershed. Such purchases, if authorized, should be made by the Forest Service of the Department of Agriculture under the approval of the National Forest Reservation Commission.

TABLE 5.—*Purchase areas*[1]

Area	Acres	Area	Acres
Additions to the Ouachita National Forest in Arkansas	313, 240	Kentucky-Cumberland area in Kentucky	900, 000
Additions to Ozark National Forest in Arkansas	120, 000	Kentucky area in Kentucky	478, 000
Additional forest in Oklahoma	855, 355	Pearson Hills area in Alabama	478, 000
De Soto area in Louisiana	230, 000	Levissa Fork area in West Virginia and Kentucky	800, 000
Jackson area in Louisiana	500, 000	Tug Fork area in West Virginia	430, 000
Little River area in Louisiana	85, 600	Elk and Gauley area in West Virginia	629, 000
Licking area in Kentucky	323, 000	Homochitto area in Mississippi	25, 000
Pine Mountain area in Kentucky	450, 000	Wisconsin River area in Wisconsin	100, 000
Quicksand area in Kentucky	268, 000		
			6, 985, 195

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[1] For location of proposed reservations, see fig. 8.

Probably not more than 85 per cent of the total acreage of these areas would be purchasable by the Government for protection forests. No land more valuable for farming than for forestry should be acquired. In mineral regions titles should be limited to surface rights, the present owners retaining their property interest in the minerals with the right to remove them under terms equitable both to the owner and to the public. In round numbers the total of purchasable land within the areas listed is estimated at 5,900,000 acres. The cost at an estimated average of $5 per acre totals $29,500,000, or an average of $2,950,000 a year if spread over a period of 10 years.

This does not include the additional areas from which lands are being currently approved for purchase by the National Forest Reservation Commission within national forests already created under the Weeks law. The purchasable lands not yet acquired within such limits on the Mississippi watershed are estimated at about 2,642,000 acres. This added to the 5,900,000 acres additional herewith recommended would make the total of forest-land purchases on the watershed proposed as a Federal activity, 8,542,000 acres, with a total expenditure of $42,721,000, or $4,272,100 annually if spread over a period of 10 years. Including the national forests already created from the public domain or acquired under the Weeks law, the total area of protection forests owned by the Federal Government in the Mississippi Basin would thus ultimately become 25,822,000 acres. This is slightly over 16 per cent of the forest lands on the drainage, or about 3 per cent of the total area of the drainage.

Even with the Federal Government assuming this part of the burden, there are still large areas where public forests, State, county, or municipal, would appear to be the only satisfactory solution. The field for local initiative will still be large enough to tax to the utmost the possibilities of State, county, and municipal forest ownership and leave a large field for private ownership. This is particularly true of that part of the Cumberland Plateau lying within the State of Tennessee, where the State legislature has not given its consent to purchases by the Federal Government more than 20 miles west of the North Carolina boundary. The problem will also be a difficult one in the State of Mississippi. Changes in the present enabling legislation of the States, with respect to Federal purchases under the Weeks law, may require some modifications in the purchase areas listed above for Federal action.

FARM WOODLANDS

The most difficult part of the forest problem on the Mississippi drainage is that having to do with the 115,000 square miles of forest land in farms and in regions primarily agricultural. This naturally arises from diversity of area, location, character, and ownership. The problem is exceedingly complex. The land is within the absolute control of millions of individual independent farm owners who are usually unaware that other interests may be injured if the hillside forests are overgrazed, burned, or cleared off.

Though the lumberman may be fairly charged with a large share of responsibility for unwise forest destruction, it is only fair to state the fortunate circumstance that after he has destroyed the virgin forests by utilization—wise or otherwise as the case may be—he usually moves on and leaves the field to nature and her curative processes, also, unfortunately, to the merciless inroads of repeated fires. With the farmer the situation is different. His settlement is permanent in design. His stability is nearly always a splendid virtue, invariably so if the land which he clears and cultivates is suitable for permanent farming. Where he makes a mistake and clears land that quickly loses its fertility under the wash of rainfall, he is reluctant to give up the fight. So much of his labor has gone into the land itself and must be abandoned if he goes elsewhere that he refuses to surrender, and only does so when driven to the utmost extremities of poverty. The process of trial and error in the use of land for farming was started in the Mississippi Valley by the first settlers who crossed the mountains at the headwaters of the eastern tributaries of the Ohio River about Revolutionary days and has been going on ever since.

As a people we are still somewhat young and inexperienced. Like the young man who fancies his inheritance is inexhaustible, we fancy that soil fertility is a fixed condition inherent to land in the very nature of things, and we clear land on steep slopes and use it for intertilled crops where similar land in older countries would either be kept in forest or would be terraced before being plowed. The fact of excessive soil erosion from farms is so conspicuous in every report on a drainage unit including considerable quantities of farm lands that it becomes the outstanding finding of this study.

This excessive erosion is taking place from three classes of lands: (1) Lands originally prairie which are too steep in slope for cultivation and should be kept in sod and used for pasture or hay lands; (2) lands along the margins of streams or in narrow draws where trees are the only growth strong enough to withstand soil washing and bank cutting; (3) most important of all, land originally timbered on slopes too steep for tillage without terracing. In some places the proportion of such land under plow is considerable. The report on one drainage unit where soil erosion is particularly malignant shows that 30 per cent of the total area under plow was abandoned between 1920 and 1925, largely because of soil losses. The serious damage appears usually to be limited to a few acres in a place—a steep slope here, a gully there, an unprotected stream bank, or the like. However, in the aggregate much greater damage is in many regions taking place in the insidious form of sheet erosion, often without the owner of the land realizing that injury is being done to his own property, to say nothing of the fact that a national problem is being made more difficult. The damage by gully washing is more obvious.

From any one piece of land in the Mississippi Valley the contribution of eroded soil is usually small, but the aggregate would make an impressive total. Furthermore, from certain highly vulnerable soils the contribution of silt tonnage is often enormous. In addition, the adverse effect on water storage and water flow of the neglect of a small area may be far-reaching. A single gully of less than a quarter of an acre may add more to the destructive power of a flood than the clear run-off of an entire section of well-managed fields or woods. The misuse of farm soils is not again peculiar to one class or region. It is far too common north, south, east, and west.

This fact of the mismanagement of farm soils runs through all the unit reports. Through all the reports there also runs evidence of mismanagement of farm wood lots owing to lack of technical knowledge or advice. The most prevailing fault is overgrazing, often to the extent of killing out all undergrowth and young reproduction within the reach of stock, exposing the tree roots as a result of soil washing and tramping, and preparing the way for the loss of protective litter from winds sweeping through the open parklike growth. All this greatly reduces the value of the area either as a timber-producing property or a soil and moisture conserving property. In most cases also the pasturage is of low value. In consequence of the overgrazing of farm wood lots and the erosion of farm lands being so general and so widespread, it appears best to cover the farm wood-lot and farm-soil erosion problem for the Mississippi Valley as a whole rather than for each major basin separately.

How to secure better management of farm wood lots is largely a question of education and extension. It involves awakening to action, based upon better understanding, the owners of the 115,000 square miles of wood lots and waste land lying within farms. The importance of this problem from a national standpoint was recognized by the Senate Select Committee on Forestry in its report which resulted in the enactment of the Clarke-McNary law, June 7, 1924. Sections 4 and 5 of this law provide for cooperation through the States with the owners of farm wood lots.

It is understood that the Senate committee's endorsement of wood-lot appropriations was based primarily on the national economic importance of the wood lots from a wood-supply and agricultural-betterment standpoint. If this work is at all worth its cost by reason of such returns, then by all means it may well be speeded up on account of its contribution to the regulation of stream flow. At first thought the use of farm woodlands may appear to be a minor factor in flood control, but such is not the case. We are dealing with very great acreages. If by the stimulation of better management of farm wood lots we can bring about an average increase of 2 inches in the layer of humus, that means an increase in water-storage capacity of 1,815 cubic feet for each acre so transformed. On a total of 115,00 square miles the increase in water-storage capacity would amount to 133,854,000,000 cubic feet, or the equivalent of the entire average run-off of the Mississippi River system above Quincy, Ill., averaging 72,899 second feet, for a period of over 21 days, or a flow of 1,000,000 second feet for over 37 hours. The resulting effect of mechanically retarding run-off would be very much greater.

We have also to consider the possibilities of forest planting on eroding farm lands as a check to erosion. Experiments conducted by the Missouri Agricultural Experiment Station showed that six plots having a gradient of only 3.71 to the hundred handled under different conditions—not cultivated, plowed 4 inches, plowed 8 inches, planted in wheat annually, planted in corn annually, rotating corn, wheat, and clover—lost soil at an average rate of 23 tons per acre a year over a six-year period, as compared with an average annual loss of about 562 pounds on a seventh plot under sod. The farm lands in the Mississippi Valley which should be planted to forests are waste lands and lands which can not be cultivated or retained in sod as pasture or meadow land without excessive erosion. Such lands are usually much steeper than those employed in the Missouri experiment. Gradients in excess of 5 per cent and up to 15 per cent or even 20 per cent are not uncommon. Under such conditions even heavier erosion might properly be expected. Successful forest planting would in 5 to 10 years reduce the average annual loss by erosion to a negligible factor. The present appropriation of $75,000 a year for aiding timber planting on farms, under the Clarke-McNary Act, can be credited with stimulating the planting on farms of 30,000 acres during 1926, which would not have been reforested without this contribution. If half of this expenditure and half the acreage is in the Mississippi Valley on sloping land similar to that in the Missouri soil-erosion experiment, this would mean eventually the withholding of about 345,000 tons of silt burden from our streams each year as a result of this 1926 expenditure, or slightly more than 9 tons of silt for each dollar originally expended. This would make the cost to the Federal Government of a single year's service less than 11 cents a ton. Spread over a period of 11 years, it would be 1 cent per ton.

But it should not be forgotten that the appropriation for planting farm wood lots was not made primarily for flood-control purposes. It was made for farm-land betterment and to help safeguard the Nation's future timber supply. Therefore, in estimating the importance of this work it must be given credit for the soil fertility which is saved from being irrecoverably lost and for the value of the wood crops, as well as for the increase in the moisture-holding capacity of the land by leaf-litter accumulation, for the greater permeability of the soil, and for the prevention of siltage in streams.

From the standpoint of the public benefits realized for each dollar of Federal money expended on flood-prevention forests, the greatest returns may be expected from that part of the Federal funds authorized to be appropriated under section 4 of the Clarke-McNary law which is used in the stimulation of planting on eroding or other waste lands in private ownership. The owner furnishes the land, plants the trees, and continues to look after them entirely at his own expense, while the most the Federal Government and State do is to help furnish the planting stock and give advice. The landowner, of course, owns the timber when it grows up, but his timber protects the watershed of the great river just as effectively as though the public had paid the entire bill.

Along with this activity must go cooperation under section 5 of the Clarke-McNary law, which authorizes the Secretary of Agriculture to cooperate with the States in assisting "the owners of farms in establishing, improving and renewing wood lots, shelter belts, windbreaks, and other valuable forest growth and in growing and renewing useful timber crops." The close relationship between these two sections is shown by the fact that 23 States in the Mississippi drainage are now cooperating with the Federal Government under section 4 and 21 under section 5. Under section 4 the farmer is aided in securing suitable forest-planting stock at a cost which makes planting a practical business venture. Under section 5 he is given expert advice in caring for his wood lots and other forest growth. Planting stock and tree seeds must be provided to restore forests on the 10,000 square miles of idle or waste lands in farm ownership in the Mississippi Basin. The farmers also need advice in managing the 105,000 square miles of farm woodlands which do not require planting but whose improvement will add greatly to the protective forest cover on the drainage.

It is desirable that additional funds be provided for Federal encouragement of forest planting on lands in private ownership in the Mississippi watershed as rapidly as the States are organized to extend this work and the owners can be induced to plant up their waste and idle land or eroding slopes. The increase in funds for giving advice on the care of farm wood lots should keep pace with the needs for such service.

This is undoubtedly the most practical method of solving the forest-watershed problem on lands best suited for forest purposes in farm wood lots and regions predominantly agricultural. The expenditures by the cooperating States in this work are already more than double that of the Federal Government, although the section 4 expenditures are usually returned to them in the form of receipts from sales of planting stock. The private cooperator is enabled through the operation of this law to secure his planting stock at actual cost of production. Without such a provision the costs of planting farm wood lots are usually prohibitive.

By this arrangement the expense to the private owner of forest planting in small areas is greatly reduced and progress in this improvement of stream-flow conditions correspondingly accelerated. It is estimated that there is a total of 22,400,000 acres of waste land in the Mississippi Basin requiring reforestation, of which 6,400,000 acres is in farm ownership. While much of this land is not eroding, none of it is in a satisfactory condition from a water-storage viewpoint. In the long run it is certain that the reforestation of this land would be a splendid economic investment from a national standpoint, particularly under a policy whereby the private owner bears four-fifths of the costs. On the basis of 1926 figures the present arrangement works out as equivalent to a Federal subsidy of about $2 50 per acre for every acre planted. However, owing to the necessity of purchasing land and starting new nurseries, the present unit costs are high. With a larger acreage and well-established nurseries, equivalent service can be furnished in the future at lower cost.

All the waste or wasting land in the basin should be reforested within 20 or 25 years. It will not be done unless strong public assistance and backing are given. Under the existing conditions the Nation appears to face a $56,000,000 task if the Government must contribute $2.50 per acre for every acre needing reforestation. It is believed, however, that with experience in planting and in managing and marketing forest products and with the realization of the resulting benefits, the private owners will take sufficient interest in putting their lands in condition to grow steadily in value without further effort except protection from fire, so that further planting subsidy will be unnecessary. The final cost to the Federal Government of securing the restoration of the 22,400,000 acres of waste lands to forests should not exceed a total of $5,000,000, or less than 25 cents per acre. Doubtless technical advice under section 5 of the Clarke-McNary law will always be necessary, since there is always a new generation of landowners growing up and since better methods of forest management will doubtless be worked out as time goes on.

PLOWLAND ALSO NEEDS ATTENTION

Extension activities in forest planting and forest management should be coordinated with extension activities in promoting better practices in farming slope lands, such as contour plowing, crop rotation, keeping steep lands in sod for hay or pasturage, and terracing according to the degree of slope and danger of washing. Wiser selection of lands for cultivation should be urged so that on lands agriculturally submarginal, and hence more productive for forest than farm crops, agriculture should not be attempted. County agents everywhere should advise against clearing slopes for cultivation unless the owner of the land is prepared to take whatever action may be required to prevent erosion and preserve the fertility of the soil. Owners should be encouraged to check further damage to their fields not only in order to prevent soil depletion but to secure the advantage of heavier crop production which follows effective terracing and the more productive use of rainfall.

There should be no conflict between the campaign for better farm practice and that for better forest practice on farm lands. The general aim should be to protect soil fertility from being destroyed by either unwise use or neglect. Unless the farmer is prepared to prevent the rich topsoil from washing away on sloping land, he should keep it in trees. However, the forest may properly be displaced whenever the productive value of the land for other purposes makes it more profitable to so use it, taking into account the expense of terracing or other soil conservation costs, if such protective work actually follows clearing.

There will always be some erosion from farm lands and some loss of soil fertility which is avoidable only at unreasonable cost. The practical application of the remedies herein proposed would not be a burden on agriculture. On the other hand, heavier crops under terracing and contour plowing and through prevention of land destruction and soil impoverishment by reforestation or sodding of slopes will offset the original cost of the necessary protective measures many times over. It is estimated that within 20 years it should be possible by an aggressive campaign of education and extension to bring about a general application of the principles stated in the two preceding paragraphs, which in turn should reduce the total silt burden now coming from cultivated fields in the Mississippi Valley to not more than 25 per cent of its present volume. Present practices would have to be changed on a very great acreage of farm lands in the aggregate although on a relatively small part of the total area under cultivation. Such an extension campaign seems to be justified by its direct economic advantages. At the same time, without additional costs it would make a very material contribution to flood prevention by reducing the burden of silt and by increasing the absorptive and storage capacity of lands now most subject to rapid run-off.

No recommendations are made as to legislation, organization, or appropriations for such a campaign of extension, since it does not come within the jurisdiction of the Forest Service. It has, however, appeared necessary to consider this feature of the flood and forest problem at some length in order to determine fairly the relative importance of forestry in conserving soils and moisture on farm lands. Such a campaign of rural education falls within the field of jurisdiction of the extension service of the Department of Agriculture.

THE PLACE OF PROTECTION FORESTS IN REGIONS PREDOMINANTLY AGRICULTURAL

However, the fact must be reckoned with that there are some agricultural regions in which the problem can not be solved by the resident owners with assistance of the kind mentioned above. In some regions the broken topography and large extent of forest lands on slopes which are subject to erosion present a difficult problem, too difficult for satisfactory solution under diversified private ownership. In such places the only final answer seems to be public ownership and management in blocks of several thousand acres. Examples of this kind are not uncommon in the unglaciated region east of the Mississippi River from the mouth of the St. Croix River south to the vicinity of Beloit, Wis. Again, in the southern part of Illinois forest lands form a continuous belt stretching for many miles along the bluffs. Timbered bluffs are also not uncommon in southern Minnesota and in Iowa and Missouri. In the latter State, in regions largely devoted to agriculture, large blocks of true forest lands, rough and unsuited for cultivation, are not uncommon, particularly in the southern half of the State. Indiana, Ohio, Kentucky, and Tennessee also furnish many examples of similar conditions outside the rougher mountainous region.

In all the States named, from Wisconsin to Tennessee, practically continuous areas of forest lands in rough country, in tracts ranging from 5,000 to 50,000 acres in extent, are not unusual. Such forest lands are not within the territory which the National Forest Reservation Commission has under existing policies considered for Federal purchases. However, these rough timbered regions appear admirably suited for public forests, probably under county, city, or State ownership, and the individual States appear well able financially to assume this burden with ultimate public profit. Such enterprises, well and profitably managed locally, should go far toward stimulating local pride and self-reliance. This, in turn, would increase local initiative, self-confidence, and self-help—which it is in every way desirable to stimulate in preference to dependence upon Federal aid and leadership.

In addition, there are considerable areas of bottom lands now in forests which these States might well purchase and retain for timber production, recreation, and overflow purposes. At present high waters are allowed to spread out on such bottom lands, the current is slowed down, and the sediment settles and is kept out of the main channels. Under private ownership there is always danger of such land being dyked or leveed, thereby accentuating both the local and general flood problem. The Federal Government is making a good start in purchasing bottom lands for wild-life refuge purposes along the middle reaches of the Mississippi River as indicated in Figure 8. The purchase of critical areas of overflow lands on the tributary streams should not place an unreasonable burden on each State directly concerned.

NATIONAL FORESTS, NATIONAL PARKS, PUBLIC DOMAIN, AND GAME-REFUGE FORESTS

In the interest of simplicity it is desirable to deal with the national forests, national parks, and public-domain and game-refuge timbered lands as a separate problem from non-Federal forests. Table 6 shows by square miles the gross area of national forests within the Mississippi drainage basin by States and major basins.

TABLE 6.—*Gross areas of national forest lands, by basins*

State	Ohio	Upper Mississippi	Missouri	Arkansas—White	Red—Ouachita	Total
	Square miles	*Square miles*	*Square miles*	*Square miles*	*Square miles*	*Square miles*
Alabama	57.3					57.3
Arkansas				1,651.6	798.0	2,449.6
Colorado			4,487.7	2,080.4		6,568.1
Georgia	498.6					498.6
Illinois		16.7				16.7
Kentucky	35.3					35.3
Minnesota		464.2				464.2
Montana			14,013.6			14,013.6
Nebraska			323.6			323.6
New Mexico				107.0		107.0
North Carolina	1,890.3					1,890.3
Oklahoma					96.3	96.3
Pennsylvania	1,155.1					1,155.1
South Dakota			1,986.6			1,986.6
Tennessee	1,343.8					1,343.8
Virginia	333.9					333.9
West Virginia	828.6					828.6
Wyoming			7,445.5			7,445.5
Total	6,142.9	480.9	28,257.0	3,839.0	894.3	39,614.1

On the Mississippi drainage there are also three large national parks having important bodies of timber—the Glacier, having an area of 160 square miles in Montana; the Rocky Mountain, 208 square miles in Colorado; and the Yellowstone, 2,864 square miles in Wyoming and Montana.

For the total area in the national forests and parks the general statement can be made that the continuance of existing policies will meet watershed-protection requirements in a satisfactory degree. The lands in the national forests and national parks are being protected from fire and managed either for their forest or scenic values. A considerable part of these lands within the exterior boundaries of national forests and national parks, particularly in the Ohio Basin and in Arkansas, is still privately owned. However, they are all either within purchase units or in national forests where acquisition by exchange is authorized, and ultimately all lands not more valuable for agriculture or some other purpose than for forest or park purposes may be expected to pass into public ownership unless existing laws are repealed.

But such is not the case with the forest lands of the public domain. These lands are Federal properties for which Congress has established no policy further than to restrict their addition to national forests by presidential order. There are a number of areas adjacent to existing national forests which have been examined by field agents of both the Departments of Agriculture and Interior and found suitable and valuable for national-forest purposes. Such areas have been recommended by both departments and by the National Forest Reservation Commission for inclusion in national forests, and the reports have been transmitted by the President to Congress for action. No action has been taken on these areas by that body. There are still other areas of forest lands in the public domain awaiting further consideration and study by the Forest Service, but for which the information now available is not sufficiently definite to permit the drafting of legislation in other than general terms.

Generally speaking, the remaining areas of forest lands in the public domain are not yet in bad shape from a water-control standpoint although far from being in as satisfactory condition as the adjoining national forest lands which have been systematically protected from fire and overgrazing for the past 20 years or more. However, with increasing demands for various kinds of wood products, these unreserved forests are eventually certain to be misused. They should be put under Federal forest management by including them in adjoining national forests instead of waiting until the damage is done and then undertaking the generation-long task of rebuilding resources which were negligently and unnecessarily allowed to be destroyed. If Congress will give the President power to act direct, the Forest Service can within 90 days submit final recommendations covering all the public lands on the Mississippi watershed in Montana, Wyoming, Colorado, and New Mexico, which are suitable for inclusion in national forests. The total areas of unreserved Government forest lands on the watershed of the Mississippi River which should be added to existing national forests would probably not exceed 700 square miles.

Another Federal land activity having a direct bearing on the Mississippi flood problem is the purchase by the Bureau of the Biological Survey of the Department of Agriculture, under a special act of Congress, of the overflow lands directly tributary to the main channel of the river from Wabash, Wis., to Rock Island, Ill. This area, which is known as The Upper Mississippi River Wild Life and Game Refuge, is shown in Figure 8. Its gross area is 265,000 acres, of which 165,000 acres is land and 100,000 water.

The forests along the stream margins come within the classification of protection forests, since they are most effective in preventing the cutting of banks. Furthermore. public acquisition of these overflow lands safeguards their being held as tributary reservoir areas available during overflow periods. Under private ownership there was always the menace that at some future time they, too, would be dyked or leveed for farms, the channels narrowed accordingly, the upper flood waters correspondingly hastened, and the problem below Cairo intensified.

THE BAD LANDS AND THE BREAKS

Two outstanding examples of serious regional erosion of nonforest lands are so clearly connected with regions of general Federal ownership and are so important from a stream-flow standpoint that their omission from this study would be shortsighted. These are the Bad Lands and the Breaks.

In the Missouri River Basin in North Dakota, South Dakota, Wyoming, and Montana are a number of areas, most of which are indicated in Figure 6, which are familiarly known as Bad Lands. A large part of these lands is in the public domain and is of no known value or of practically negligible economic value. The Bad Lands aggregate about 15,500 square miles and form a great single class of land having an enormous effect on erosion and run-off.

Space does not allow a detailed description of typical Bad Lands. It is sufficient for the purposes of this circular to say that they have a clay soil and very scanty cover. The character of the precipitation of the Bad Lands regions is similar to that of the region of the Missouri experiment. Unquestionably from these areas comes a considerable part of the silt which gives the Missouri the name of "Big Muddy." In this connection it is worth while to note that the Missouri River is clear at the junction of the Jefferson, Madison, and Gallatin at Three Forks, Mont. It is usually still comparatively clear at Great Falls and Fort Benton, once the head of navigation. Its mountain tributaries come from national forests or from two great national parks, the Yellowstone and the Glacier. They come from the regions of steepest slopes and heaviest precipitation of the northern part of the basin, but because of the protection given to these watersheds by the Federal Government's national forests and parks, the streams are clear and pure. As soon as the river begins to receive the run-off from areas of Bad Lands it immediately takes on a muddy character which it retains until it transmits its burden of water and silt to the Mississippi River.

No data are available showing quantitatively the amount of silt contributed to the Missouri by Bad Lands areas. However, very good data have been published by the Missouri Agricultural Experiment Station showing the amount of soil eroded from a bare slope having a gradient of 3.71 per 100. In a six-year period during which the average annual precipitation was 35.87 inches the average loss was 34.95 tons per acre annually. The average annual precipitation for the Bad Lands regions is about 15 inches. The average slope would undoubtedly be much greater than 3.71 in 100. If the Bad Lands erode as readily as the Missouri soils and in direct ratio to the total precipitation the contribution of these 15,504 square miles would be annually 15,500×640×34.95×(15 divided by 35.87), or over 144,000,000 tons. An unpublished report of the War Department estimates the annual discharge of solid matter by the Missouri as 413,000,000 cubic yards, or, at 2,700 pounds per cubic yard, about 557,000,000 tons. It thus appears that approximately 26 per cent of the total sediment contributed by the Missouri River may come from 15,500 square miles of country, or less than 3 per cent of the watershed. If we take Dole and Stabler's figures (1909) of about 180,000,000 tons as the usual sediment carriage of the Missouri, the Bad Lands contribution is 79 per cent of the whole. This is no doubt too high a proportion.

These calculations are not presented as being of direct or immediate value in determining flood factors. They are, however, believed to be of value as indicating sources of trouble which should be carefully investigated. They make clear the fact that the great influence of these areas, and the possibilities that some means may be found to reduce their destructive power by vegetative covering, justify making the Bad Lands a matter of special research. As properties they would attract private enterprise only as they might be made to produce remunerative crops. As a Federal responsibility they present other responsibilities, such as checking the burden they contribute to the silt problem of the Mississippi and possibilities of eventual reclamation for some useful purpose.

A serious erosion problem somewhat analogous to the Bad Lands of the northwest is presented by the Breaks of the southwest. This is the region which marks the boundary or break between the Staked Plains of the Texas panhandle and the lower rolling red prairie country to the east. The steepness of the escarpment between the lower edge of the Breaks and the High Plains seems to be due generally to a rock cap which underlies the plains and preserves their surface until undermined and broken off.

The rain falling on the High Plains is almost entirely soaked up by the soil. The run-off, and consequently the erosion, occurs in the Breaks themselves, which extend back along the valleys being cut by the upper tributaries in Texas and western Oklahoma.

Soil erosion is extremely active through the Breaks region because of a combination of many steep slopes, scanty vegetation, abundance of easily eroded soil, and sudden hard rains. It is from this region that the Arkansas and Red Rivers draw their first great burden of silt, and it is this source of silt which the population of those two great drainage basins must reckon with in their plans for development, including the storage of water in reservoirs for irrigation, power, municipal supply, or other purposes. Unless the burden of silt carried by the local streams can be greatly reduced, the storage capacity of reservoirs in that region will be diminished very rapidly.

Merely from a flood-prevention and erosion standpoint it is believed that the Bad Lands and the Breaks are of sufficient importance to justify special study and investigation. The method of stopping erosion is a problem for research. Several species of trees and shrubs, together with many hardy grasses, grow in the regions, but the task of establishing them where extreme drought conditions prevail for long periods of time, and on bare slopes which disintegrate rapidly and wash away, promises to be extremely difficult. Meanwhile overgrazing is accelerating the progress of erosion.

It seems desirable that a special research project for the specific purpose of working out some system of protecting the Bad Lands and the Breaks and stopping the excessive erosion now taking place in these regions should be undertaken. It is an interstate and national problem, and seems to be one which could best be solved in a limited period of active study as a special project. This should not be primarily a forest project, but foresters should participate in the work. What is most urgently needed is some kind of vegetative cover to bind the soil, and regulated use to prevent its destruction when once established. This cover may be trees, brush, vines, or grass, whatever proves best. The Forest Service, through its experience in tree planting, its study of range plants, and its experience in practical range management, should be able to help in working out some practical remedy for each region. The major objective of the project should be to work out some means of producing more favorable conditions for run-off control and reduction of erosion, and not necessarily for developing economically valuable products; it is possible, however, that products of use in industry would be realized later.

SUMMARY OF CRITICAL AREAS

Figure 6 shows graphically the location and extent of what are reported to be the most critical areas in the Mississippi Valley judged by their need of forest cover to prevent erosion or flashy run-off. These lands are divided into three classes, detrimental, neutral, and beneficial, according to the present condition of forest cover, and, as Table 7 shows, are located in 30 States.

TABLE 7.—*Extent of the Mississippi River Basin critical areas (gross)*

State	Influence on flood conditions			
	Detrimental	Neutral	Beneficial	Total
	Square miles	*Square miles*	*Square miles*	*Square miles*
Alabama	4,922	1,015		5,937
Arkansas	1,477	13,628		15,105
Colorado	123	108	11,251	11,482
Georgia	31	569	615	1,215
Illinois	12,598			12,598
Indiana	6,153			6,153
Iowa	17,182		275	17,457
Kansas	1,538		218	1,756
Kentucky	13,244	10,890		24,134
Louisiana	2,446	154		2,600
Maryland		461		461
Minnesota	5,538		1,056	6,594
Mississippi	10,798			10,798
Missouri	15,844	9,967		25,811
Montana		277	18,227	18,504
Nebraska	154		1,477	1,631
New Mexico			3,276	3,276
New York		308		308
North Carolina	1,169	2,261	2,400	5,830
North Dakota			133	133
Ohio	8,845			8,845
Oklahoma	16,551		677	17,228
Pennsylvania	2,907	6,245		9,152
South Dakota			2,966	2,966
Tennessee	12,706	7,399	1,907	22,012
Texas	292	3,599		3,891
Virginia		3,184	446	3,630
West Virginia	6,676	12,613		19,289
Wisconsin	8,691	2,246	846	11,783
Wyoming	46	62	18,443	18,551
All States	149,931	74,986	64,213	289,130

Table 7 deals generally with forest lands and does not include either the Bad Lands or the Breaks, which are also included in this circular and recommended for special study. These areas are classified as detrimental treeless areas and embrace a total of 32,471 square miles distributed among certain Western States as shown in Table 8.

TABLE 8.—*Areas of Bad Lands and Breaks*

The Bad Lands		The Breaks	
State	Area	State	Area
	Square miles		*Square miles*
Colorado	31	Kansas	1,646
Montana	10,121	New Mexico	154
North Dakota	3,845	Oklahoma	3,861
South Dakota	1,507	Texas	11,306
Total	15,504	Total	16,967

These 32,471 square miles of critical treeless areas, added to the total of 289,130 square miles of critical areas based on forest requirements make a grand total of 321,601 square miles, gross. of critical areas out of a grand total of 1,231,492 square miles in the Mississippi watershed. This amounts to about 26 per cent of the entire watershed.

However, the only areas in which anything like 100 per cent of the acreages outlined are actually critical are the Bad Lands and the Breaks. These are not included in the following discussion, which applies specifically to areas where forests are a critical factor in run-off and erosion conditions.

Many of the areas are mapped as critical because they include a considerable percentage, usually 10 per cent or more, of lands on which the retention of forests or the restoration of forests is important to prevent flashy run-off and serious soil erosion. In some regions these lands are found in innumerable small tracts scattered throughout lands which are not critical. This applies particularly to the critical areas shown in States and localities which are primarily agricultural, and with special force to the critical areas as mapped in Illinois, Wisconsin, Minnesota, Iowa, and northern Missouri. In the region of greater forest-land density the proportion of lands actually critical in character within the areas shown as critical may run as high as 80 per cent or more. This applies particularly to the critical areas outlined in Louisiana and Arkansas, and in eastern Tennessee, Kentucky, West Virginia, and Pennsylvania.

The acreage actually critical is roughly estimated at 150,000 square miles, out of the gross critical acreage of 289,000. The acreage thus estimated as critical all comes within the broad classification of forest land, actual or idle, totaling 244,000 square miles for the entire Mississippi drainage. This leaves an estimated total of about 94,000 square miles of forest land in the valley having soil and topography of such characteristics that the presence or absence of forest cover has no marked influence on erosion or stream flow therefrom. The 150,000 square miles of critical acreage, added to the acreage in the Bad Lands and the Breaks, gives a total critical acreage of 182,471 square miles within the limitations of the study for the entire Mississippi Valley.

PUBLIC-DOMAIN GRAZING LANDS

With very few exceptions, each individual drainage unit which embraces any considerable acreage of unreserved public domain suitable for grazing is reported as being injured by overgrazing and unregulated grazing, with destructive erosion taking place over large areas. No data are available to show to what extent this results in increasing the rapidity of run-off. From a flood standpoint, except for local freshets, such increase would not be material. The burden of silt which misused grazing lands contribute to the Missouri and Arkansas must, however, in the aggregate be very great.

These lands are open to entry under the various public land laws, consequently the acreage is slowly dwindling. The total area of public lands in the Mississippi Basin, according to the report of the General Land Office of the Department of the Interior, July 1, 1926, It should, of course, be understood that appropriations or expenditures are suggested or recommended only upon condition that they be made at such times and in such amounts as may be in harmony with the fiscal policy of the Government.

First in order of importance is the extension of fire cooperation under section 2 of the Clarke-McNary law. The blanket of organized protection should be extended to all forests on the Mississippi watershed as rapidly as the States and private owners are willing to undertake the work. Ultimate cost per year for entire watershed about $490,000. This includes all forest lands as well as "critical areas," for flood control, since it is impractical to attempt a definite separation into classes for protection purposes. This would be accomplished with the appropriations now authorized by the Clarke-McNary law.

Idle waste land on farms and submarginal land used agriculturally should be planted to forests under the Clarke-McNary Act as rapidly as the States and private land owners will expand such work and as cooperative expenditure will be in accord with the fiscal policy of the Government.

Instruction to owners of 115,000 square miles of forest land in farm ownership should keep pace with planting and need for advice in use and marketing forest products.

The purchase of about 2,642,000 acres of protection forest lands in national forest purchase units already approved and established by the National Forest Reservation Commission on the Mississippi watershed should be completed and in addition approximately 5,900,000 acres of protection forest lands adjoining two existing national forests in Arkansas and in 15 other units on the Mississippi drainage should be purchased. Inclusive of forest lands still to be acquired in completing units now approved under the Weeks law the total amount of land would be 8,542,000 acres. These purchases could be made under the provisions of the Weeks Act and Clarke-McNary Act during a period of from 5 to 10 years, subject to the appropriations authorized under the fiscal policy of the Government.

Protection and administration of present national forests, parks, and game refuges should be continued under present policies; and adjoining forested areas of unreserved public domain should be added to national forests.

Investigations of the Bad Lands and the Breaks should be authorized as a research project with a view to discovering some method of preventing serious erosion.

The plan of control of public grazing lands recommended by the Secretary of Agriculture and the Secretary of the Interior should be adopted. Expense, nominal appropriation to start. After starting activity will be self-supporting from fees.

Provision should be made for securing a permanent record hereafter of stream-flow measurements and silt content of the Mississippi River at some point below Cairo and on each of the principal tributaries entering the river below that point and data essential to a long-time study of land use and erosion remedies thereby secured.

CONCLUSIONS

If these recommendations are carried out, a reasonable effort will have been made to take advantage of the power of good forest cover to hold water and soil and thus to play its part in restraining the violence of floods and erosion. Just how great or how small this influence would be in a vast watershed like the Mississippi no one can ever say, for the forces involved are too vast and complex for measurement. Yet such quantitative measurements as are available, combined with the cumulative force of common-sense observation and circumstantial evidence, point clearly to the conclusion that this influence is too important to neglect.

The benefits of good vigorous forest cover do not end with their ameliorating effect on stream flow and silting. Keeping our forest soils in place instead of letting them waste away to clog our river channels, making those soils fully and perpetually productive—these objects in themselves justify large investments in protecting and restoring our forests. Such investments are financially sound because they will pay interest and dividends in timber products, and the resultant benefits in river protection will be a by-product without cost.

Forest rehabilitation is not urged as an alternative to engineering works for flood control. It is supplementary to the engineering program, but it is a supplement of such importance that no complete plan of flood control can omit it.

ACKNOWLEDGMENT

Space does not permit the inclusion of the names of the various individuals and agencies who have contributed to this report. Such a list would be a directory of people interested in the conservation of forests, streams, and water resources generally in the central United States. All State foresters and other officials, local, State, and Federal, have been most helpful and generous in contributing to an understanding of actual conditions as herein reported. Space limitations also compel the omission of a bibliography.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

August 17, 1928

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THE THINKER
—*by Kessler*

Boston Transcript.—It is difficult to realize that there are people of unquestioned intelligence in this country who do not seem to realize our timber situation.

FORESTRY AND THE FOREST PROBLEM

By Charles Lathrop Pack

President American Tree Association

FORESTRY is a general term susceptible of varying definitions according to the opinions of the definer. Broadly it might be said that to practice forestry is to apply concrete scientific principles to the growth and utilization of timber crops. It does not mean laws compelling the planting of a young tree for every old one cut; regulating the sizes and kinds of trees to be cut; controlling private enterprise by government. It does mean the re-creation of forest resources by the best means conceivable, and use of the existing resources with the minimum of waste.

Forestry, in the strict sense, is a science. It relates to the properties of wood; the best uses to which it can be put; the best conditions under which it can be grown. Management is an economic science applied to forestry, and an increasingly important and appreciated phase of the question. Forest fire prevention, and insect and disease control and eradication are vitally important factors in the bigger issue.

Beyond the questions of the planting, growing, and protecting of forests, there is the broader question of the "forest problem." These two words represent something that concerns every citizen. The science of forestry must be left to trained men who dedicate their life to the work, but the solution of the forestry problem rests with the intelligent and informed activity of the people of the nation. Their action must reflect an aroused appreciation of the importance of the forest in their economic and social life.

What is this problem? Estimates place the original forests of the United States at 822,000,000 acres. Today there remain 138,000,000 acres of virgin forest; 250,000,000 acres covered with second-growth timber or young trees of no commercial value and 81,000,000 acres of land—fitted for no other purpose than forest growth—that are barren and unproductive of anything. Including virgin and second-growth timber, then, it is estimated that 42 per cent of our original resources are left. Furthermore, we are using our remaining resources between four and five times as fast as they are being reproduced.

In addition to the condition of depletion, there is a serious dislocation of our remaining forest assets from the point of view of geography. Three-fourths of the land lies to the east of the Great Plains. In this section, where industrial enterprise has been built with a large measure of dependence upon wood, however, is found only 25 per cent of the virgin timber and 40 per cent of the merchantable stand. Thus, 75 per cent of the virgin timber and 60 per cent of all the timber is found in the Rocky Mountains and in the states of the Pacific Coast.

The bulk of the remaining resource east of the Plains is concentrated in the South. The industrial states of the northeast and the central and lake states are dependents for their forest resources, in contrast with original forests sufficient to sustain them. In all of these states there are from one to six million acres of denuded, unworking land. These states pay an enormous annual freight bill for their timber, and in no few cases the transportation cost of the timber is equal to what the timber itself cost delivered 30 years ago.

We have, then, a problem of dependent states, of dislocated sources of supply of idle lands and of continued rapid inroads into our remaining assets. It is a situation that has gradually been brought to the attention of the public until there is a fairly widespread and intelligent sentiment concerning the situation. At the same time that the public education has been going forward, the Federal Government and the states have been doing what they can to prepare for the future.

There have been set aside about 156,000,000 acres as National Forests, administered by the United States Forest Service. They are being judiciously cut, protected from fire, and reforested as rapidly as resources permit. The majority of the states have taken action in one way or another to create departments charged with the protection and rebuilding of forest resources. In some cases cities and towns have entered upon active forest policies.

Governmental acquisition of additional forest areas is an essential part of the forestry program. The McNary-Clarke Act broadens the type of lands which may be acquired, and Federal action to add to its present forest resources must be carried forward. This must, however, be supplemented by extension of forest ownership on the part of the States, some few of which now own large areas and others none. In the town and municipal forest movement there lies another valuable phase of public ownership, meaning increased local supply of timber as well as an economic benefit to the community, and the lead taken by Massachusetts and

New Hampshire in this work is a fine one to follow.

Yet, withal this public acquisition and ownership of forest lands represents a vital part of the program, private ownership must remain the backbone of our timber industry. Government acquisition is in large measure concerned with lands that must be reclaimed and built up again into timber assets. Private lumbering must go on as an essential part of our economic structure. At the same time it must be made profitable to practice forestry on privately-owned lands. This means tax revision, elimination of waste through efficient utilization and introduction of the best methods of scientific administration of the forest areas.

On the scientific side, both the Federal Government and the states have established stations for research and experiment in the fields of utilization and sylviculture. More than a score of the institutions of higher education have established schools to train technical foresters, and many others provide general courses in the economics of forestry, or on forestry for the farmer.

The principle of fifty-fifty cooperation between the Federal Government and the States has become a part of legislative policy. It is particularly applicable to the forests, which are a national resource and necessity. The Weeks Law emphasized this policy in the matter of fire protection, and the McNary-Clarke Act reaffirms it in this particular and others. The chief problem now before us in the forest program—after adequate appropriations have been assured—is to secure this cooperative activity on the part of the States. Meeting our forest problem requires teamwork if ever a national problem did.

The forestry movement toward the solution of the forestry problem has gained rapid momentum. Progress has been made to a point where the vital need of a definite forest policy, coordinating the work of the nation and the states, is beyond question. The necessity of tax adjustments that will encourage reforestation is plain. The need of redoubled efforts to protect the forests from the drain of fires and disease is obvious. Reforestation, more careful management, elimination of waste, are among the items that must be incorporated in such a policy.

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THE MORNING PAPER
WHEN THE FORESTS ARE GONE

Courtesy of "LIFE"

STEVENSON
IN THE BROOKLYN DAILY EAGLE
SAYS:

OUR forests are being depleted at the rate of 25,000,000,000 cubic feet annually, while the growth of our forests is only 6,000,000,000 cubic feet annually.

"How long can we stand this drain?" writes Frederick Boyd Stevenson in the Brooklyn Daily Eagle.

"It has been estimated that the original forests of this country consisted of 822,000,000 acres. Today there are 138,000,000 acres of virgin forest; 250,000,000 acres of second-growth timber or young trees. Including the second-growth timber and young trees, which, of course, are now of no commercial value, it will be seen that about 42 per cent of our original resources remain.

"But there are 81,000,000 acres of land suitable for no other purpose than forest growth. These acres should be utilized by the government and steps at once taken to make them productive of future trees.

Unless we do provide for the future in a commercial way the timber supply of this country—like the oil supply—will become exhausted in a comparatively short time.

"What are we going to do to meet this situation?

"The fact that we are using our remaining forest resources about four times as fast as they are being produced calls for prompt action.

"Charles Lathrop Pack, president of the American Tree Association and one of the best authorities on forest preservation, says:

> "'In addition to the condition of depletion there is a serious dislocation of our remaining forest assets from the point of view of geography. Three-fourths of the land classed as actual and potential forest land lies to the east of the Great Plains. In this section, where industrial enterprise has been built with a large measure of dependence upon wood, however, are found only 25 per cent of the virgin timber and 40 per cent of the merchantable stand. Thus 75 per cent of the virgin timber and 60 per cent of all the timber is found in the Rocky Mountains and in the states of the Pacific Coast.
>
> "'We have, then, a problem of dependent states, of dislocated sources of supply, of idle lands, and of continued rapid inroads into our remaining assets.'

"Here is the answer:

"Cooperation between the Federal Government and the State Government not only to preserve the forests but to create forests.

"No man in this country has been more interested, has devoted more time to the subject, and has done more for the preservation and expansion of forestry in the United States than Charles Lathrop Pack. He organized and is President of the American Tree Association. He has established forestry foundations in seven schools of forestry and he has presented 1,000 acres of forest land in the Adirondacks to the New York State College of Forestry at Syracuse University to be forever dedicated to demonstration and research and the forest uses of the college.

"In addition to his donation to Syracuse

University, Mr. Pack has for years been writing and talking about the preservation of our forests. He has just issued through the American Tree Association 'The Forestry Almanac,' which is replete with data and information concerning our forests. This is one of the most useful books every published on this subject and will have a great influence in bringing about greater preservation, conservation, and creation of American forests.

"Suppose the Federal Government, at the head of a United Forest Policy, should get all the states and all the universities and all the private forestry associations to cooperate and have a single definite forestry plan—would not much greater results be accomplished?

"Suppose, now, that the scope of this National Conference be enlarged and that it unite with the National Forestry Program Committee in an earnest endeavor to have all the states and the Federal Government combine in a cooperative movement to save and increase the forests of the United States to meet the growing demands for timber in numerous lines of industry.

"Would not practical results follow if these two organizations should appoint an All-State Committee with Charles Lathrop Pack as Chairman, this committee to have authority to call a Congress to devise ways and means to bring about direct Federal and state cooperation with the one object in view of—

"Conserving, preserving, increasing, and creating forests in the United States?

"Is not some such move worthy of attention?"

New York Herald-Tribune.—There is sound sense in the suggestion of Charles Lathrop Pack that agreement instead of argument is needed in the forest policy of the nation. There must be law, there must be education, there must be public agitation, and all efforts must be co-ordinated in one consistent and persistent forest policy.

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Houston Post.—Charles Lathrop Pack, president of the American Tree Association, told the New England Society that the people of that section of the country were paying $3,000,000 per year in freight rates on forest products which they formerly produced at home. At the present rate of cutting and in the absence of a comprehensive effort to replenish the timber areas, the time cannot be far distant when we will be following the New Englanders in buying lumber at distant markets and adding millions in freight bills to our building costs.

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Louisville Times.—The American Tree Association points out, in comment upon the statement of the Chamber of Commerce of the United States, that firewood today is one of America's important crops. While farms in America are running out of their natural fuel, towns in Switzerland burn wood from municipal forests one thousand years old.

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Manchester Herald.—New England is paying about three million dollars a year to import lumber to keep her factories going, according to Charles Lathrop Pack, president of the American Tree Association. The statement, coming in terms of dollars, should appeal to Connecticut people as a fit subject of economic discussion. Eighty-one million acres of land lie idle. We must put those acres to work growing trees, he says, for "the economic leadership and even the future safety of the country depends upon it."

Atlanta Journal.—What if the production of wheat were to cease, so that we should have to depend for flour on the reserves in grain elevators? Answering this, its own question, the Jacksonville Times-Union says that there would be nation-wide outcry against the peril of such a situation, and that even if the production were one-fourth of the consumption, there would be grave anxiety and protest. "Yet, important as the products of the forest are in modern civilization, people learn with complacency that the forests are being used up four times as fast as nature can renew them —four times as fast as the trees still standing can grow." Every state, certainly every one east of the Mississippi, has urgent reason to act upon this situation, not only by conserving timber resources but also by providing new reserves against lean years ahead.

* * *

Chicago Tribune.—Timber farming has not been profitable in the United States. Though shortages increase, though the freight and charter bill alone on timber is $250,000,000 annually, raising timber has not been thus far a profitable possibility. The passage of the McNary-Clarke bill may improve the situation.

* * *

Albany News.—What is imperative now is a definite tree-planting, reforesting policy by State and Nation that will plant trees by the millions, by the thousands of acres that are now waste land, and keep on planting every year. This should be made the business of Nation, State, county, town, village, and school, and landowner. It must be done.

* * *

Pittsburgh Post.—Need for the adoption of a national forest policy can be seen in these facts. Most of our forests have disappeared. The great center of lumber production is now in the Pacific coast states. The American people are consuming wood about four times as rapidly as the remaining forests are producing it.

Oakland Tribune.—Forests in this country are being depleted at the rate of 25 billion cubic feet of timber annually, while the growth each year is but 6 billion cubic feet. How long can the country stand the drain? If it is agreed that this is an uneconomic and unhealthy situation, what is to be done? At last the legal machinery by which the denuded lands may be replanted has been supplied. The drain on the forest area continues. The thing to do is to plant trees on those idle acres.

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Dayton News.—Put the matter on a purely economic basis, a contribution to the nation's resources, and we cannot but be impressed and impelled to get busy. The longer we put this matter off the worse the situation becomes, because we are felling trees hourly in America without supplanting them. If this does not stop we shall be called upon some day, or the next generation will, to pay the price.

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Los Angeles Times.—The people should see that Congress attends to this vital need by letting Representatives and Senators understand that the voters are strongly in favor of preventing the total destruction of our American forests, so leaving our children at the mercy of the foreigner for one of our prime necessities—wood.

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New York Telegram-Mail.—The great forests of the past are gone. The center of the lumber industry moves farther and farther west. Much of the cost of living that we complain about is due to the increased cost of forest products.

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St. Joseph Herald-Press.—As a result of the violation of Nature's laws, Charles Lathrop Pack asserts, New England is paying three million dollars in freight rates on forest products every year when she ought to be producing close to her factory doors.

New York Times.—How serious is the problem of supplying the growing demand in this country for pulpwood, the basis of the manufacture of paper, is set forth in a comprehensive bulletin of the Department of Agriculture. Our consumption of paper for all purposes in 1922 was 8,000,000 tons—more than was used by all the other countries in the world. Newsprint paper is made of wood pulp. Of the total paper consumption in 1922 newsprint called for 2,450,000 tons, or 31 per cent of the total requirements. Writing paper of the finer kinds was used to the amount of 350,000 tons. Wrapping paper passed the million-ton mark. Papers "classified under boards" were 27 per cent of the total. To account for the remainder, blotting, hanging, fiber, carbon, tissue, crepe, wax, manila, imitation parchment, leatherette, carpet felting, tar and building papers were only a few of the miscellaneous kinds in daily use. In 1919 wood supplied more than 90 per cent of the raw material for the paper made in the United States. By 1950 we shall be using 11,250,000 tons of paper. The United States is the world's greatest paper market. European production is comparatively small. Therefore it is an arresting fact that less than a third of the original timber stand of the Continental United States remains.

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Des Moines Capital.—The United States is suffering a tremendous economic loss so long as it fails to carry out complete reforestation of this great area of idle land.

◆

Milwaukee Sentinel.—In the old days when the land was covered with virgin timber, wasteful methods were passed by unnoticed and the necessity for replacing the trees taken was so remote that a national policy of neglect grew up.

◆

Christian Science Monitor.—When it is remembered that there are 81,000,000 acres of land, mostly east of the Mississippi River, fit for nothing but the growing of trees, the need of a progressive forest policy is at once apparent.

Birmingham News.—This vital need for conservation finds expression in the McNary-Clarke bill which passed both houses of Congress. This protective measure comes in due time to save America from the fate that came to China and other oriental countries centuries ago, and to protect American forests in much the same manner that the Europeans have saved their wooded areas from devastation and exploitation. That is what it is proposed to accomplish through the McNary-Clarke law.

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Columbus Dispatch.—With the individual demonstrations of success in such projects constantly increasing, the almost utter lack of concern with the question which has marked the past, and the timid and halting attitude of the present, will alike give way to a general and intelligent determination to put to work our potential timber lands which are now lying waste, and to make obligatory the scientific cutting and immediate reforestation of cut-over areas in the great forest reserves still under government control. The pinch of high-priced paper will have done a good work if it shall hasten the coming of an intelligent forestry policy for America.

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Chattanooga Times.—There isn't a great deal of land in the country, at least in the eastern part of the country, upon which timber will not grow if planted. Reforestation will not accomplish itself. The new forestry law makes the government a sort of clearing house for cooperation in a forest policy with the states.

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Dearborn Independent.—Our forests are being consumed four times more rapidly than they grow. The timber shortage has become one of the most critical and vital problems of today.

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Philadelphia North American.—It is a proposition of immense importance to the future of our people because our forests are the backbone of agriculture, the cornerstone of lumbering, and the actual heart of industry.

Pittsburgh Press.—The forest fires which have been devastating large areas in the western states will not have been an unmixed curse if, through the attention they have attracted they lead to the adoption of measures which will save other timberlands from destruction. It was doubtless this though that Charles Lathrop Pack, President of the American Tree Association, had in mind in pointing to the Western forest fires as "the annual lesson the American public some day will learn." If the people were seriously impressed by the disaster and made to see the need for taking steps to avert such blazes, the destruction of the forests, regrettable though it is, would not have been without use. Better to learn through a painful lesson than not to learn at all. Mr. Pack indicates one way in which the forest fire loss may be cut down. In a letter which he has sent to the governors of various states he points out that if they desire to benefit from the McNary-Clarke Forestry Act passed by Congress recently they must enact legislation appropriating money for forest fire protection. The Federal legislation authorizes appropriations to match the amounts provided by the states.

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Washington Times.—One thing that Congress did just before the death rattle was to pass a forestry bill. This stands out as a constructive piece of legislation. It is the beginning of a national forest policy in this country, the only one in the world without one. The measure requires cooperation of the states in voting money for increased fire prevention methods among other things, and everybody says it is a great big forward step. Now let the states act.

⁂

Nashville Banner.—This country cannot afford to neglect any reasonable means of rousing greater public interest in the matter of reforestation. For decades we have cut and slashed recklessly, and then allowed the cut-over lands to be swept by fire until the problem is gradually becoming an acute one in many parts of the United States.

THE PART OF GOOD CITIZENS:

A PEOPLE without children would face a hopeless future; a country without trees is almost as helpless; forests which are so used that they cannot renew themselves will soon vanish, and with them all their benefits. When you help to preserve our forests or plant new ones you are acting the part of good citizens.

—Theodore Roosevelt.

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Department of Social and Public Service

Social Service Series Bulletin Number 28

Conservation of National Resources

Report of the Conservation Committee
of the American Unitarian Association,
Doctor George F. Swain, Chairman

Published for free distribution
American Unitarian Association
25 Beacon Street, Boston

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Prefatory Note

For some years past the conservation of our national resources has been the subject of much discussion. There has been abundant reason for it. Until recently we have seemed to think there was no end to the vast wealth with which America has been endowed, and we have wasted recklessly our timber, our coal, oil, iron, gas and other resources at an appalling rate. Our waters are not properly utilized, the soil is being impoverished, minerals exhausted, wild life exterminated, and if we continue in our improvidence the end of some of our most valuable natural assets will soon be in sight. Those who know the facts are calling a halt and the country has at last begun to realize that a check must be put upon waste, that conservation must take the place of extravagance. How this is to be done is the great question. The problem is so vast that it is hard for the individual to relate himself to it, and yet it can only be solved by each individual doing his part. Prof. Swain's monograph is particularly valuable because he points out definite ways in which every one can advance the policy of conservation upon which the future of the country so largely depends.

E. S. F.

Conservation of National Resources

Report of the Conservation Committee
of the American Unitarian Association,
Dr. George F. Swain, Chairman

Our forefathers came to this country some three hundred years ago. They had been brought up in the various countries of Europe, and their experience and that of their ancestors had taught them the virtures of puritanism,—economy, industry, simplicity, frugality, humility, and reverence. They found a land of boundless opportunity, of marvelous richness, practically untouched by the hand of man; and this land they and their descendants, and the others who have joined them, have been developing during the past three centuries. At first they suffered many discouragements and hardships in combating the adverse forces of nature, but, as the years went by and the earth yielded her richness into their hands, the comforts available began to multiply, and with their multiplication the ancient virtues have been gradually less and less observed, and, in some classes, seem now to have largely disappeared. Wealth increased

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The Committee of the American Unitarian Association on Conservation of National Resources consists of George F. Swain, Chairman, Professor of Civil Engineering, Harvard University, Cambridge; James A. Tufts, Professor in Exeter Academy, Exeter, N. H.; Charles R. Van Hise, President University of Wisconsin, Madison.; William P. Brooks, Professor in the Massachusetts State Agricultural College, Amherst, Mass.; George H. Glover, Professor in the Colorado State Agricultural College, Fort Collins, Col.

rapidly; and science, progressing with rapid strides, made available to men's hands all the boundless riches of the new land. It was no longer necessary to practice frugality, for there was more than enough for all. The homogeneity of the population, and the establishment of a form of government which did not recognize the inequalities between men, while it fostered a certain degree of individual self-confidence, decreased the sense of humility. The statement in the Declaration of Independence that "all men are created equal"—meaning, of course, that all men are equal before the law—gradually became misunderstood and perverted until it is now widely considered to mean that all men are intrinsically equal and deserving of equal respect and the same opportunities. At present, the young grow up in an atmosphere which leads them to feel that they are in every respect the equal of anybody else, and respect for age and wisdom is rare. Advice is, therefore, seldom sought or thoughtfully received. The rich have become numerous—not those who have been rich for decades, like the aristocrat of Rome—but the newly rich, whose riches have come as if by magic through the development of the country.

Ferrero, writing of the condition of Rome, uses the words: "The destruction of Carthage and Corinth had already worked serious havoc in Roman life, spreading luxury and ostentation among the upper classes, a distaste for work among the lower, and wastefulness and intemperance in all ranks of society." In the case of America, it has not been the conquest of other countries which has brought wealth, prosperity and material progress, but the conquest of the land, the marvelous development of the riches of the virgin continent. The result, however, is precisely the same as that described by the historian of Rome. *Waste and extravagance have become common; frugality has, in large measure, given place to improvidence.*

There is no doubt that the time has come when a halt should be called, and when the serious condition which confronts us should be realized. While the resources of our country have not by any means been exhausted, they have been consumed at an alarming rate. Our forests are already half gone, and we are taking from them each year approximately three times what they produce. Our supplies of coal, iron, gas, oil, fertilizers, and other material resources, are being consumed at a rate which, in the case of some of them at least, apparently indicates a definite end in sight. Our waters, instead of being utilized, are allowed to go to waste and to cause destruction where they should be of service. Our soil, instead of being conserved, is wasted by erosion and by unwise methods of cultivation. If all this consumption of our resources were legitimate, if there were no waste, we might be justified in going on without pause, leaving to future generations to take care of themselves. The fact is, however, that much of our consumption of these resources is wasted—absolutely thrown away.

How can this situation be met? Not alone by newspaper articles, meetings of societies, or the reading of papers or publishing of books on conservation, but only as the individual man may be made to realize the situation and realize it keenly, and as he may be made conscious of the necessity for doing something, and of what he individually can do.

The problem, then, appears to be to bring the situation, the necessity for action and the remedies which may be adopted, to the consciousness of the individual. Such would seem to be the real problem of conservation. This, of course, is promoted, to a certain extent, by publicity, by holding meetings, by the writing of books and papers; but we all know how little such things affect the individual, unless something more powerful is brought in to reinforce them. Books and papers may be read and then put away or thrown into the waste basket, and the extravagance goes on as before. As Mark Twain said about the weather, we all complain about the weather, but nothing is done.

It would seem that the ministers of the churches might help in this matter by bringing to the attention of their congregations, not necessarily through their sermons, but by their personal influence, the seriousness of the situation. To this end, the first step would seem to be to secure the necessary references and publications, in order that they may inform themselves concerning the problem. A series of references, therefore, has been collected, and appended to this report is a bibliography of the subject. Two publications, however, may be specially mentioned, which are easily available, and which will probably be more than sufficient for most readers, and these may be briefly referred to.

1. The great mine of information on this subject is the report of the National Conservation Commission, which was published by the Government Printing Office in 1909, as Document 676, 60th Congress, Second Session. This report is in three volumes. It consists of the message of the President, the report of the Commission, statements by the secretaries of the different sections, and appendices, in which almost every topic under the general heading is exhaustively treated.

2, The second source of information is the book entitled "The Conservation of Natural Resources in the United States," by President Van Hise of the University of Wisconsin, published by the Macmillan Company in 1910. This treatise contains a resume and discussion of the report of the National Conservation Commission, in which all the important elements are brought out and clearly explained. It should be in the hands of everybody who wishes to inform himself regarding this subject.

The reader who possesses these works, and who reads them carefully, will find many leads which he may desire to follow in special directions. For the convenience of readers, the appendix contains a classified list of specific references, taken largely from the work of President Van Hise, just referred to, from which appendix the mass of literature on this subject will be apparent.

WHAT THE INDIVIDUAL MAN CAN DO TO PROMOTE CONSERVATION

The question still remains, what can the individual do to promote conservation? As a matter of fact, there are many things which each one of us can do; and, simply as a suggestion, there is appended the following brief and incomplete list of things to which attention may be directed.

1. First of all, one can endeavor to focus his attention on the subject of waste, and to keep before his mind each day the fact that it is his duty, so far as possible, to avoid waste of any kind. Each day also, he may ask himself what he is doing definitely to carry out this object. If once attention is focused on the matter, innumerable opportunities will be found. We are all thoughtless and careless, we are creatures of habit, we do things mechanically and without thinking. Let us get out of this rut and try to realize more consciously the effects of our actions upon ourselves

and others. Among the things which each one of us can do, a few may be mentioned.

Some of the things which we may suggest will seem perhaps trifling; such, for instance, as avoiding waste in lead pencils and matches. If they do, it will perhaps be because we have forgotten the precepts of our ancestors, such for instance, as " Many a little makes a mickle; " or, Benjamin Franklin's aphorism " Take care of the pennies and the dollars will take care of themselves." Conservation will not be promoted as it ought to be if attention is focused only on the big things, for the big things are almost invariably made up of smaller things, and economy in the latter will necessarily produce economy in the former; indeed, it is not so much any one precise thing that a man can do that is of importance, as it is the attitude of mind which he presents toward all things. If we could become imbued as a nation with the proper attitude of mind, it would not be necessary to say anything more regarding conservation.

WASTE OF TIMBER

2. Few of us are dealers in wood or its products. Those who are will have many opportunities, if they will realize it, to avoid waste, and by proper methods of logging and manufacturing, to avoid the destruction of what is not needed, and to use more completely

the timber which it is necessary to cut. In the use of timber, for instance, certain parts of a tree are used for one purpose, and other parts for other purposes. Thus far there has been little co-ordination, and in some sections of the country immense quantities of lumber have been allowed to rot away on the ground after the removal of the portions which it is desired to use, although these portions thus wasted would be extremely valuable if put to some other use. For instance, in parts of the country where tanning is done, trees have been stripped of their bark and the remainder allowed to die or rot. This shows the importance of a proper co-ordination of industry. It points directly to the desirability of the so-called "tandem method" of organizing a large industry.

Those who are not dealers in or manufacturers of products of the forest, may still have abundant opportunities to practice economy in their use. For instance, we all of us use lead pencils. Few of us realize, however, the enormous amount of wood which is used in their manufacture and is absolutely wasted as the pencils are used. As a matter of fact the wood from which lead pencils are made is generally cedar because of its straight-grained quality and its softness. Immense quantities of this timber are used in the manufacture of lead pencils, and it is stated that the supply is being seriously reduced and not replenished. Recently, one of the large railroad companies computed that it could save a large sum each year if all its employees would utilize the stubs of lead pencils which are usually thrown away, and it took some steps to endeavor to require such use. Why can we not use some form of gutta percha, or other permanent pencil which requires only the leads to be inserted, and does away entirely with the use of wood? Many forms of such pencils are manufactured; one form, patented in Germany and costing very little, being known as the Penkala. Why should we destroy good timber when we can avoid its use entirely, except, perhaps, for drawing purposes, for which pencils have to be very sharp.

When we realize the large amount of wood that is used each year in our fire-places and for kindling, the subject of lead pencils may seem to be too trivial for mention; in reality however, it is not so. The wood used in our fire-places is largely wood which could not well be used for any other purpose, either because of its short length, its character of grain, or the practical impossibility of making any other use of it. The farmer provides his fire-place from his wood lot; but even if this were valuable for some other use, it would probably not pay to collect the comparatively small quantities burned by the individual farmer and convey them to some central manufacturing establishment. The waste of fire wood, however, is no doubt itself carried to excess, involving much waste. We have an open fire, not because we need the warmth, but because we like its looks and it seems cheerful. This, strictly speaking, is not conservation—though, within reasonable limits, it may be conservation of health.

3. Railroad companies use enormous quantities of railroad ties each year. By preserving them, their life may be largely increased, but preserving adds to the cost. It cannot be expected, in a case like this, that treated timber will be used unless it proves in the end more economical than untreated timber. As a matter of fact, it is believed by many competent authorities that at the present prices, and with the use of proper preservative processes, the treated ties are the more economical. The same may be said of wood for other purposes, such as many purposes of construction, fence posts, etc. Even if the economy were the same in the two cases, allowing for the cost of the preservative process, longer life, etc., a due regard for the conservation of our resources should lead, in such a case, without question to the use of treated timber.

4. The loss by conflagration in this country reaches figures which are almost incomprehensible. Our dwelling houses are largely of wood, they decay, and large amounts are paid annually to the insurance companies to protect the owner against fire loss. In European cities wood is much less used. Even at some greater initial expense, it is very probable that in this country structures of a more permanent and non-inflammable

character, such as brick or concrete, would, in the end, if everything is taken into account, prove as economical in many instances as wood. Let each individual who contemplates building a house, or using wood in any form, consider at least, with care, the possibilities and the economy of some more permanent material. Let him take account of the interest, the probable life, the cost of renewal, the price of insurance, and all the other elements entering into the problem, and let him not use wood unless it is distinctly more economical.

5. Matches. To refer to the waste in matches may seem even more trivial than the waste in lead pencils. Nevertheless, there is no question that the quantity of wood consumed in a year for matches is something incredible and no doubt a large part of this is wasted. For this wood a straight-grained timber is generally used, and the smallness of the product leads to the cutting of many young trees, which, with proper conservation, should be allowed to grow. The portable saw-mill perambulates about the country in the interest of the match companies; a tract of woodland is bought from a farmer, and, instead of being cut economically, using only the mature trees, it is swept clean, and the life of young, sound timber, which in a few years would be suitable for larger and more important purposes, is ruthlessly sacrificed. It is probably impracticable to bring about much reduction of this waste,

but we might all do a little if we could alter, to some extent, our attitude of mind. In the first place, we often use too large matches. A large size is used where a small one only is needed for an instant, and three-quarters of a match is thrown away. By using smaller matches, and by using as far as practicable some of the modern substitutes for the wooden match, a saving might be made which, in the aggregate, would amount to a larger sum than most of us imagine.

MINERAL RESOURCES

6. We are all of us wasteful in one way or another of mineral resources, among which are included coal, gas, oil, etc. We leave gas burning, or electric lights turned on, and lamps burning, when we could just as well, and better, turn them off. We burn more coal than is needed in our stoves and furnaces, keeping our houses too warm for health and comfort. Let each of us see if he cannot get along with less of these materials. In our use of iron and other metals, too, we are wasteful. We do not keep them well protected by paint, or otherwise, from corrosion, although it would be distinctly to our ultimate advantage to do so.

SOIL

7. With reference to the conservation of our soil, those who are engaged in farming can do much, by rotation of crops and by the prevention of erosion, to conserve their productiveness. One of the most serious

problems for us as a nation is the conservation of soil fertility. The reckless robbing of the soil of American farmers portends disaster for future generations, and its dire results are already felt in some existing economic conditions. This waste is due partly to erosion, partly to unwise methods of cultivation, and partly to the continual withdrawal of valuable elements without replacing them. It is not generally recognized how serious a waste is going on through erosion, and few realize the fact that our rivers are transporting to the sea as sediment the most valuable portions of our soil. This erosion is, of course, most serious on steep slopes, but moderate erosion is continually taking place on vastly larger areas where the slope is comparatively moderate, resulting in a far greater total loss of soil. Every man and woman, but farmers particularly, should be made to see the importance of reducing erosion.

Another source of loss of fertility results from taking out of the soil year by year the same valuable constituents. Rotation of crops would to some extent prevent this, and, with proper use of fertilizers, would largely increase the productiveness of our farms. A campaign of education among farmers with reference to these points is greatly needed. They will be found fully discussed in the report of the National Conservation Commission, and in other books and articles to which reference is made in this report.

One thing which might be greatly encouraged in this country is tree planting, which not only increases the timber supply, but on steep slopes prevents the erosion of the earth. Let us spread the gospel of tree planting, and see to it, if possible, that we bring about the planting of some young trees every year.

WATER

8. With reference to the conservation of the waters, there is much that each individual can do. One great source of loss to the community is the excessive waste which takes place in most municipal water supplies. It is well that the use of water should be common, and that every individual should be encouraged in cleanly habits, but the free use of water leads to an enormous waste, the magnitude of which is seldom realized. In some of our cities the consumption of water is 150 to 200 gallons per day for each person in the population. Such a use is illegitimate and extravagant. Statistics show that less than 100 gallons a day, and in some cases considerably less, is ample, if waste is prevented. The proper amount of consumption will, of course, depend upon circumstances. Manufacturing establishments use considerable water; much is used for sprinkling lawns in the summer time, depending upon the climate. There is no question, however, that on account of leaky fixtures, carelessness in allowing water to run when it ought to be shut off, allowing it to run

in the winter time in order to prevent freezing, and in countless other ways, a tremendous expense is actually entailed upon the community.

The average cost in American cities of a gallon of water is about .005c. If a supply of, let us say, 60 gallons per capita per day is sufficient without waste—and the experience of cities which have meters indicates that this, under ordinary circumstances, would be ample—it follows that if 100 gallons per capita per day are used, each individual wastes during the year an amount of water costing $0.73; while, if 160 gallons are used per capita each day, each individual wastes per annum an amount whose value is $1.82. If the population of a city is 100,000, the total waste at 100 gallons per diem is $73,000 per annum, and at 160 gallons per diem is $182,000 per annum. These figures indicate into what large sums the waste from this source may run.

In the above paragraphs, the object has been to put in a concrete form some illustrations of the opportunities which will present themselves to the individual man for advancing the cause of conservation. Dependent upon his surroundings and his business, every individual will find many opportunities to advance this cause, but unless he realizes this in a concrete way, and takes advantage of his opportunities, newspaper articles, periodicals and books on this subject will produce but little effect.

There is grave danger that some, and perhaps much, of the progress which has been made will be lost. There is at the present time no unity of action throughout the country. Wise laws would undoubtedly much help the cause of conservation. These laws should be partly national laws, passed by Congress, and partly state laws, passed by the state legislatures; but these should in all cases be properly co-ordinated, so that they will all work together for a common purpose. With Congress pulling in one direction, and state legislatures in another, and perhaps in an opposite direction, the cause of conservation will not be promoted, but will be seriously hindered.

The Congress of Governors, called together in 1908, was productive of much good, not only in inducing wide-spread interest in the subject, but in promoting harmony of feeling between all sections of the country. The various irrigation congresses which are held from time to time, and particularly the Conservation Congress held each year, promote the same object. It cannot be too strongly emphasized, however, that complete harmony of action is necessary for the best results, and that the individual, the professional societies, the states and the nation, should unite in taking immediate, uniform, and energetic action to keep awake the interest in the subject, and, by well-devised and harmonious laws, as well as by the widest publicity, to promote this great cause, upon which our future as a nation so largely depends.

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